Fraser River Estuary Monitoring

Report on the 1989 Boundary Bay Monitoring Program

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REPORT ON THE 1989 BOUNDARY BAY MONITORING PROGRAM

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SUMMARY

During June 1989, sediment, fish, crab, and clam samples were collected from Boundary Bay and subsequently analyzed for metals, PCBs, PAHs, chlorophenols, phthalate esters, and organochlorine pesticides. Sediment samples were also collected adjacent to five pumping stations which are the only direct discharges to the Bay, and from the mouths of three tributaries to Boundary Bay: the Serpentine, Nicomekl, and Little Campbell rivers. These rivers carry contaminants which might originate in the drainage areas removed from the Bay itself.

QUALITY ASSURANCE / QUALITY CONTROL

Several quality assurance/quality control (QA/QC) measures were used by the laboratory to validate the results in this report. For metals analyses in both tissues and sediments, reference materials with certified values were used to determine the accuracy of the measurements reported by the laboratory. To ensure contamination was not present, samples of digestion blanks for metals and extraction blanks for organic contaminants were measured. For selected organic contaminants, the percent recovery of spiked samples at ten times the detection limit was measured. Precision for both metals and organics was determined by performing duplicate analyses of individual measurements. In total for the results reported herein, these QA/QC measures for metals accounted for 40 % for sediments and 45 % for tissues, and 47 % and 37 %, respectively, for the organics.

Accuracy was determined by analyzing certified reference materials. The results for arsenic, cadmium, lead, mercury, and zinc were generally accurate in both sediments and tissues. For chromium, the results were generally accurate for all the tissues but were low for sediments. The results reported for copper were accurate for sediments, and generally accurate for all the tissues at lower concentrations but low at higher concentrations, thus underestimating real levels.

In terms of precision as determined by performing duplicate analyses for the same sample, the results for arsenic, cadmium, and zinc were generally within 20 % for tissues and 10 % for sediments.

Chromium and mercury values were precise within 20 % for both tissues and sediments. Copper values were precise to within 10 to 25 % for most tissues and within 15 % for sediments, depending upon the concentration. The results for lead were generally precise to within 30 % for most tissues and within 15 % for sediments.

Contamination was not normally present in extraction or digestion blanks, except for phthalate esters. For this group of chemicals, the highest concentration in the blanks for each phthalate was used as a value below which the data were considered as indicating contamination in the sample.

METALS

Sediment concentrations of arsenic, chromium, copper, and mercury were lower at most sites in Boundary Bay than found in sediments collected from the Fraser River at about the same time period, while cadmium concentrations were higher and zinc and lead concentrations were about the same. The highest values in sediments usually were for sites with the finest sized particles, with the highest concentrations usually at the offshore site near the International Boundary. Most metal concentrations in the sediments were below the lowest Apparent Effects Threshold (AET) values for Puget Sound, and therefore were not of concern.

Higher metals concentrations often were found in sediments collected in the ditches leading to the five Boundary Bay pump stations than were found in sediments from many of the sites in the Bay. This indicates that the ditches are a possible source of metals to the Bay. Lead concentrations in Boundary Bay sediments were usually highest at sites near the tributaries. It is suspected that the Serpentine and Nicomekl rivers are contributing considerable quantities of metals to Boundary Bay.

Fish collected from Boundary Bay were analyzed as whole fish except for starry flounders where the large size permitted analyses of tissues. Arsenic, chromium, lead, and mercury values in fish from Boundary Bay were lower or similar to tissue samples of fish from Burrard Inlet or the Fraser River Estuary. Cadmium, copper, and zinc concentrations in whole fish from Boundary Bay were higher than in similar species from Burrard Inlet or the Fraser River Estuary. Mean concentrations of cadmium, copper, lead, nickel, and zinc in starry

flounders were magnified in livers over concentrations noted in muscle.

Crabs (C. magister) in Boundary Bay had higher cadmium and copper concentrations than those from Burrard Inlet, while Boundary Bay crabs had lower chromium concentrations, and lower or similar mercury and lead concentrations. Crabs (C. magister) collected from Boundary Bay and Burrard Inlet had similar zinc concentrations.

Arsenic concentrations in both fish and crabs were below Food and Drug criteria for human consumption. Concentrations of lead measured in crabs and fish were well below the B.C. Environment alert level of 0.8 µg/g. An individual could safely consume about 2 000 grams of crab per week based on mercury concentrations in the crab meat. Mercury concentrations in fish from Boundary Bay were below B.C. Environment Criteria for human consumption.

CHLOROPHENOLS AND PCBs

Chlorophenol and PCB concentrations in benthos, fish, and sediments were low and always below the Water Quality Objective concentrations directly applicable to Boundary Bay, or those for the Fraser River Estuary. PCBs in starry flounder livers seem to be magnified over concentrations in muscle samples.

PHTHALATE ESTERS

Sample contamination was present for phthalates for most of the environmental compartments. Precision of the analytical procedure was also often poor, but this may have been a result of the contamination commonly associated with these characteristics.

Bis(2-ethylhexyl) phthalate was measurable at values higher than the contamination present in clams, crabs, fish, and sediments. The concentrations of this phthalate ester were usually sufficiently elevated relative to the blanks that we can conclude that there is some accumulation of this phthalate occurring.

Di-n-butyl phthalate, butyl benzyl phthalate, di-n-octyl phthalate, and bis(2-ethylhexyl) phthalate were all at considerably higher concentrations in livers than in the muscle of starry flounders, implying that magnification of these phthalates is taking place in this species.

PAHs

Both the pump stations and the tributaries are contributors of individual PAHs to Boundary Bay. The Sediment Quality Objectives for PAHs which apply to Burrard Inlet are not directly applicable to Boundary Bay, but indicate whether a concern should exist in Boundary Bay with respect to PAHs. Generally, the sediments of Boundary Bay were below the Objective concentrations. For those relatively few sites where some of the measured values exceeded the Objective concentration, concentrations in Boundary Bay sediments were below the lowest AET values for Puget Sound. This indicates that the aquatic life in Boundary Bay likely are not being affected by PAHs. Further evidence of this is the fact that PAHs could not be detected in biota from Boundary Bay.

ORGANOCHLORINE PESTICIDES

The organochlorine pesticides were not detectable in sediments from most of the sites sampled in Boundary Bay. In the ditches leading to the pump stations and near the mouths of the three tributaries, most organochlorine pesticides were near or below varying detection limits. Thus, it is difficult to determine if these are sources of organochlorine pesticides to Boundary Bay.

Organochlorine pesticides were not usually detected in the crabs or soft-shelled clams, although DDE was measured in the soft-shelled clams and in over one-half of the crab samples and in almost every fish sample from each of the two sites. Magnification in livers from muscle of starry flounders, and in hepatopancreas from muscle in crabs, was apparent only for DDE.

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1. INTRODUCTION

Boundary Bay, including its northeasterly extension of Mud Bay and its eastern section called Semiahmoo Bay, is located approximately 19 km south from the City of Vancouver. It is 15 km long and four kilometres wide, covering an area of 6 090 hectares. The Bay is rectangular in shape, and faces southeast onto the southern Strait of Georgia. Tides enter from the south and are more concentrated on the eastern side during flood tide, but are more concentrated on the west side during ebb tide.

The water quality within Boundary Bay may be influenced by Puget Sound water, entering during flood tides from the Blaine area (Swain and Holms 1988). It can also be influenced by outflows from its three main freshwater tributaries, the Serpentine, Nicomekl, and Little Campbell rivers.

Areas surrounding most of Boundary Bay are zoned and utilized for agricultural purposes. Drainage from these areas enters Boundary Bay from five land pump stations.

On April 1, 1986, a five-year agreement was concluded between the Fraser River Harbour Commission and the B.C. Ministry of Environment. The agreement related to carrying out monitoring in the Fraser River Estuary area, based on a report prepared by the Working Committee on Fraser River Estuary Monitoring (1984). The estuary area under study is from Kanaka Creek downstream.

Monitoring during 1989 was done to determine the quality of sediments, fish, and other biota in Boundary Bay, as well as to collect additional data for sediments from the Fraser River. The data for the Boundary Bay sampling are reported here, with samples having been collected from those sites shown on Figure 1.

The purpose of the monitoring was to:

1. To determine the levels of metals and organic contaminants in fish, sediments, and other biota in Boundary Bay.

2. To determine the degree to which the values meet provisional Water Quality Objectives for Boundary Bay (Swain and Holms, 1988).

1.1 SITE SELECTION

Ten sites were sampled for sediments in the Boundary Bay area during 1989, with five being opposite the pump stations , three being opposite the mouths of the Serpentine, Nicomekl, and Campbell rivers, one on the inshore near the mouth of the Nicomekl River, and the tenth being in the deep water near the International Border. The sites are shown in Figure 1.

1.2 PROVISIONAL WATER QUALITY OBJECTIVES

The B.C. Ministry of Environment (MoE) is currently establishing provisional Water Quality Objectives on a site-specific basis. One area where the Objectives have been published is Boundary Bay and its tributaries.

Provisional Objectives which are applicable for the results from this survey are (Swain and Holms, 1988):

PCBs: 0.03 µg/g (dry-weight) maximum in bottom surface sediments.

2. MATERIALS AND METHODS

2.1 FIELD METHODS

There were ten sites used for monitoring in Boundary Bay (Figure 1). As well, additional samples to supplement the information from the ten main sites were collected. All field work was conducted under contract by Mrs. Karen Hutton.

2.1.1 SEDIMENTS

Sediments were collected from ten monitoring sites in Boundary Bay (Sites B-1 to B-10 on Figure 1), as well as from one site near the mouths of the Serpentine, Nicomekl, and Campbell rivers (Sites R-1 to R-3 on Figure 1), and from just upstream from each of the five pump stations (Sites P-1 to P-5 on Figure 1).

Sediments were collected opposite the pump stations (Sites B-1 to B-5) at low tide conditions as follows. Starting 50 metres from the average high tide mark and progressing out into the Bay, five sediment samples were collected every 50 metres over a total distance of 250 metres from the high tide mark. At each of the 50 metre sampling points, three samples were collected from a triangular grid with 5 metre sides. Each of the three samples were collected from a square area with 15 cm sides and five centimetres deep, and then composited.

The samples were collected by scraping the surface with a jar supplied by the laboratory. The three samples collected at each sample site were mixed together in a Pyrex tray using a glass scraper, and then scooped into separate sample jars. The tray and scraper were rinsed with on-site water between each 50 metre sample point. Between sites, the tray and scraper were rinsed with tap water carried in glass jars, then acetone, and finally hexane. The utensils were then allowed to air dry.

The off-shore sediment samples (Sites B-9 and B-10) were taken with a Peterson dredge, and dumped into a plastic tray. The top 5 to 10 cm layer of sediment, not touching the plastic, was scraped off into a sample jar.

Sediments from the three river sites (Sites B-6 to B-8), and from upstream from the pump stations, were collected with a Petite Ponar dredge, and emptied into a glass tray, if possible. At stations where the glass tray could not be used, care was taken to ensure that the sediment had not contacted plastic or wood.

All sediments were kept as cool and refrigerated as possible, prior to delivery to the laboratory.

2.1.2 CLAMS

Clams were dug at sites B-1 and B-5 at low tide, using a shovel. Any clams broken during the digging were replaced into the hole and covered. This was done to reduce problems which might arise due to the clams becoming contaminated with sediment.

After excavation, the clams were rinsed with on-site water in nearby tidal pools, and placed into glass containers which were filled with on-site water. The clam samples were left in a cooler to depurate for at least 48 hours. Ice packs were rotated through the cooler to maintain a cool temperature. In order to isolate the clams from any sediment which gathered in the bottom of the glass containers, a layer of empty shells was kept on the bottom of the depuration container.

The clams obtained during the survey were as follows:

Organism	Sites Located	Number of Samples
M. arenaria (soft-shelled clam)	B-1	6
	B-5	5
C. nutalli (chitons-mollusc)	B-1	1
Tresus capex (horse clam)	B-1	1

2.1.3 BEACH SEINE

Benthos samples were collected from Site B-9 as follows. Crabs were collected by scooping them up at low tide, using a fish landing net or a bucket, either from a boat or on foot. A falling tide was found to be the time of greatest success for collecting the crabs. The crabs were stored in a plastic tub, and were dissected either "fresh" or frozen, the latter being the easiest to dissect.

To collect fish, a 50 by 8 foot beach seine was employed by two people on foot. Attempts to deploy the net by boat were frustrated by the abundant eel grass which fouled the boat's propeller.

Fish were placed onto a glass tray or into a jar and stored in a cooler. They were identified, their length measured, weighed, and placed into sample jars within 30 hours of collection. They were then frozen.

The following is a listing of the samples (usually composite except for crab muscle-details on the composite samples are in the Appendix) obtained using this method at Site B-9.

Organism	Number of Samples
Cancer Magister (dungeness crab)	7 muscle
	3 hepatopancreas
Cymatogaster aggregata (shiner perch)	6 whole fish
Gaserosteus aculeatus (3-spine stickleback)	3 whole fish
Leptocuttus armatus (staghorn sculpin)	8 whole fish

2.1.4 OFF-SHORE TRAWL

An off-shore trawl was used to collect benthos samples from Site B-10 located in deep water near the International Border. A commercial fishing vessel, the Kirsten F, operated by Beak Consultants, was used to carry out the trawls.

Small fish were stored in glass containers and frozen. They were later identified, their length measured, weighed, placed into sample jars, and re-frozen. Large fish and crabs were frozen in plastic or glass containers. They were later identified, their length measured, weighed, dissected, and re-frozen.

The dissections were performed using surgical quality stainless steel instruments. A Pyrex baking tray was used as the dissecting tray. All glassware was washed in a domestic-style dish washer, baked at 400 ^{o} F for three hours, then rinsed in acetone and hexane. Between samples, all instruments were rinsed with tap water, acetone, hexane, and allowed to air-dry.

An OHAUS 700 Series triple beam balance was used to weigh all material. A metric ruler placed under the dissecting tray was used for linear measurements. Samples were dissected directly into the sample container. For composite samples, tissue weight was determined by subtracting each successive individual weight from the one previous.

The following is a listing of the samples (usually composite except for crab muscle-details on the composite samples are in the Appendix) obtained at Site B-10.

Organism	Number of Samples
Cancer Magister (dungeness crab)	5 muscle
	4 hepatopancreas
Lumpenus sagitia (snake prickleback)	5 whole fish
(buttersole)	5 whole fish
Citharichthys sordidus (Pacific sandab)	4 whole fish
P. stellatus (starry flounder)	5 muscle
	3 livers

2.2 ANALYTICAL METHODOLOGY

Much of what follows has been taken directly from the report prepared for the Fraser River Harbour Commission by the contract laboratory, ASL.

2.2.1 SAMPLE PREPARATION AND STORAGE

When the samples were received at the laboratory, they were catalogued, tissue samples were stored frozen, and sediment samples were kept cool until analyzed.

The samples were prepared in a clean environment dedicated to this project. Tissue preparation consisted of homogenization and sub-sampling using a special pre-cleaned teflon and glass apparatus. Details of the numbers of individuals and their weights for each composite sample are included in the Appendix. Sediment samples were blended and sub-sampled to ensure a representative portion was taken for analysis.

2.2.2 METALS

2.2.2.1 TISSUE

All samples were analyzed in accordance with documented methods using state-of-the-art instrumentation and laboratory apparatus. The samples were analyzed in accordance with procedures outlined in the U.S. EPA 301(h) analytical protocols. Specifically, a representative sub-sample of homogenized tissue was digested using a combination of oxidizing acids. The resulting extract was analyzed for the metals of interest using various optimized atomic absorption and emission techniques. The detection methods were as follows:

Element	Instrument Detection Mode
Cd, Pb, Cr, Mo, Ni	Varian SpectrAA 300 single beam spectrophotometer equipped with a Zeeman background corrected Graphite Furnace.
As	Perkin Elmer Model MHS-20 hydride generation system coupled to a Model 2380 AA.
Cu, Fe, Mn, Mg, Zn	Perkin Elmer Model P-40 inductively coupled argon plasma spectrograph.
Hg	Pharmacia Model U.V. mercury monitor with a 30 cm absorption cell.

2.2.2.2 SEDIMENTS

All samples were analyzed using procedures outlined in Tetra Tech (1986). Specifically, a representative sub-sample (wet) of homogenized sediment was digested using a combination of nitric and hydrochloric acids. The resulting extracts were analyzed using atomic adsorption techniques, which were the same as for tissues with the following exceptions: chromium, molybdenum, and nickel were analyzed following the methods detailed for Cu, Fe, Mg, Mn, and Zn for tissues; and cadmium and lead utilized a Perkin Elmer Model 2380 dual beam spectrophotometer equipped with automatic background correction.

2.2.3 CHLORINATED PHENOLS

For both tissues and sediments, a representative portion of each sample was extracted using a modification of a technique published by Tetra Tech (1986). This procedure involves the soxhlet extraction of the sample with acidified hexane/acetone followed by solvent partitioning. The crude extract was then cleaned-up using Sephadex QAE-A25 ion exchange resin (Renberg, 1974). The resulting extracts were then derivatized using heptafluorobutyric anhydride and analyzed by capillary gas chromatography with electron capture detection, under the following conditions:

Instrument: Hewlett Packard Model 5890A

Columns: HP-1, 25 metres long by 0.32 mm i.d. by 0.17 µm film thickness
HP-5, 25 metres long by 0.32 mm i.d. by 0.17 µm film thickness

Oven: 100 °C hold for 1 minute, then 5 °C/minute to 200 °C, hold for 5 minutes.

2.2.4 PCBs, ORGANOCHLORINE PESTICIDES, AND PHTHALATE ESTERS

For both tissues and sediments, a representative portion of each sample was extracted using a modification of a technique published by Tetra Tech (1986). This procedure involves the soxhlet extraction of the sample with acidified hexane/acetone followed by solvent partitioning. The crude extract was then cleaned-up by alumina column chromatography producing various fractions containing the PCBs, pesticides, and phthalate esters. The resulting extracts were analyzed using capillary gas chromatography equipped with dual column/dual electron capture detection under the conditions outlined in Section 2.2.3, with the following modifications:

Oven: Fraction 1- 150 °C hold for 3 minutes, then 3 °C/minute to 210 °C, hold for 7 minutes.
Fraction 2- 200 °C hold for 1 minute, then 3 °C/minute to 230 °C.

Injection: 2 µL (splitless)

2.2.5 POLYNUCLEAR AROMATIC HYDROCARBONS

For both tissues and sediments, a representative portion of each sample was extracted using a modification of Procedure 21.001 (AOAC, 1984). This involves the saponification of the sample with ethanolic potassium hydroxide followed by solvent partitioning into iso-octane. This crude extract was then subjected to a clean-up procedure using phosphoric acid and solvent partitioning between iso-octane and dimethyl sulfoxide. A further clean-up procedure using silica gel column chromatography (EPA Method 610, U.S. EPA, 1984) was also employed. The resulting extract was then analyzed by capillary gas chromatography with mass spectrometer detection, under the following different conditions than outlined in Sections 2.2.3 and 2.2.4.

Instrument:	Hewlett Packard Model 5880
Oven:	80 ^{o}C, hold for 1 minute, then 7 ^{o}C/minute to 260 ^{o}C , hold for 10 minutes.

2.2.6 LIPIDS

A representative portion of each tissue sample was extracted and analyzed as outlined in the AOAC Official Methods of Analysis (1984). Specifically, a sample was extracted using a combination of chloroform and methanol solvents in the presence of an enzyme. After appropriate treatment, the lipids were determined by evaporation of the solvents and weighing the resulting residue.

2.2.7 MOISTURE

A representative portion of the sample was dried to a constant weight at 105 ^{o}C. Moisture was then determined gravimetrically by measuring weight loss upon drying.

2.2.8 TOTAL, ORGANIC, AND INORGANIC CARBON

A representative portion of each sample was leached with hydrochloric acid to remove carbonates and then analyzed for organic carbon using a Leco induction furnace. Total inorganic carbon was determined as the difference between total and organic carbon.

2.2.9 PARTICLE SIZE

Representative portions of each sediment sample were dry-sieved in accordance with Tyler (1980), and the fine materials determined by pipette method (Tanner and Jackson, 1947).

2.2.10 TOTAL VOLATILE RESIDUE

Determined gravimetrically after igniting the sample at 550 ^{o}C for one hour and cooling in a vacuum desiccator.

2.3 QUALITY ASSURANCE/QUALITY CONTROL

The following is based upon information provided by ASL Laboratories.

The U.S. EPA define Quality Assurance (QA) as the "total program for assuring the reliability of monitoring data". Quality control (QC) is limited to "the routine application of procedures for controlling the measurement process." QA is concerned primarily with the tools of the measurement system. Reagents of the highest quality were used and checked for purity, strength, deterioration with time, and contamination. Class A volumetric glassware was thoroughly cleaned and calibrated when necessary. Balances were checked frequently with certified weights and records maintained. All instruments were calibrated on a routine basis, with the maintenance of appropriate standards and operational logs on performance.

Extensive QA measures were taken to ensure that the highest level of precision and accuracy was maintained. All analyses were

performed using accepted procedures and included the concurrent analysis of reagent blanks, sample duplicates, analyte spikes, and certified reference materials, where available. Further detailed discussion of the precision and accuracy for each type of analyses is included in the following sections and chapter.

2.3.1 SEDIMENTS

Accuracy was determined for metals by measuring levels in three separate certified reference sediment samples; two of which were marine sediments prepared by the National Research Council of Canada and one estuarine sample from the National Bureau of Standards in the USA. Reference materials were not available for organics. No reference samples were submitted from the field.

Precision was determined for metals by running eight digestion blanks and 16 duplicate analyses of individual samples. For organic analyses, 10 extraction blanks and 10 analyte spikes were tested, as well as 11 duplicate analyses of individual samples.

For metals, only minor amounts of iron and magnesium were detected in the digestion blanks, indicating good contamination control. Further discussion is included for each characteristic in the appropriate section. Where the discussion relates to the precision of duplicate analyses, the percent difference between values is calculated as the difference divided by the smaller of the two values. This produces a large number seemingly less precise than if the average or maximum values were used in the calculation.

For the organic analyses, only trace amounts of phthalates were consistently detected in the extraction blanks. Considering the number of phthalate sources, their relative abundance and mobility, this was not unexpected. In fact, the only other organic contaminant found in the extraction blank was the PAH, acenaphthylene in one of the ten extraction blanks. Further discussion is included for each characteristic in the appropriate section.

2.3.2 TISSUES

Accuracy was determined for metals by measuring levels in four separate certified reference samples; three of which were

dogfish muscle, one being dogfish liver, and three being lobster tissue prepared by the National Research Council of Canada. Two mussel samples from the National Institute of Environmental Sciences in Japan were also tested. Reference materials were not available for organic contaminants. No reference samples were submitted from the field.

Precision was determined for metals by running six digestion blanks and 13 duplicate analyses of individual samples. For organic analyses, 9 extraction blanks and 9 analyte spikes were tested, as well as 8 duplicate analyses of individual samples.

For metals, none of the elements of interest were detected in the digestion blanks, indicating good contamination control. Further discussion is included for each characteristic in the appropriate section. Where the discussion relates to the precision of duplicate analyses, the percent difference between values is calculated as the difference divided by the smaller of the two values, which would produce numbers which seem less precise than if the average or maximum values were used in the calculation.

For the organic analyses, only trace amounts of phthalates were consistently detected in the extraction blanks. Considering the number of phthalate sources, their relative abundance and mobility, this was not unexpected. In fact, the only other organic contaminant found in the extraction blank was pentachlorophenol in one of the nine extraction blanks. Further discussion is included for each characteristic in the appropriate section.

3. RESULTS AND DISCUSSION

In the following discussion, when at least one-half of the results are above the detection limit, average values and corresponding standard deviations are calculated. For values less than the minimum detectable concentration, we used the absolute value of the detection limit has been used to calculate average values. If more than one-half of the results are below the detection limit, average values and standard deviations are not calculated since there is too much uncertainty with so many values less than detection.

Values cited for fish, clams, and crabs are expressed on a wet-weight basis, while those for sediments are as dry-weight, unless otherwise noted. The laboratory reported that no technical problems were encountered with any of the sediment analyses. It also reported that many of the tissue samples contained significant amounts of sediment which were only noted after decomposition of the tissue. This could affect metals data where these were at higher concentration in the sediment than in the tissue.

Generally, the fish samples analyzed were as whole fish, except for starry flounders from Site B-9, which were muscle and liver tissues. For crabs, both muscle and hepatopancreas were tested.

3.1 METALS AND METALLOIDS

The trace metals are presented in alphabetical order in the following sections. Results for the clams and crabs are in Tables 1 and 2, for fish in Tables 3 and 4, and for sediments in Table 7. All data for individual samples are in a limited number of final reports from the analytical laboratory, and on the Ministry of Environment computerized data storage and retrieval system. Discussion of metals is limited to those considered to be priority toxicants.

In the process of preparing (digesting) the fish and benthos for analyses of metals, it is possible for some contamination to occur. For this reason, six blank digestions were run (without tissue) and the extracts analyzed for all metals. For contamination to be present, measurable quantities would be present in these digestion

blanks. None were measured above the following detection limits (wet-weight):

As, Cd,	0.005 µg/g
Cr, Cu, Pb, Ni	0.010 µg/g
Fe	0.1 µg/g
Mg, Mn, Mo, Zn	0.05 µg/g

Since no contamination appears to be present due to the digestion process, corrections were not made to the data values reported by the laboratory.

Similarly, eight blank digestions were run (without sediment) and the extracts analyzed for all metals. For contamination to be present, measurable quantities would be present in these digestion blanks. None were measured above the following detection limits (dry-weight) except for one iron (1.5 µg/g) and one magnesium (0.54 µg/g):

As	0.01 µg/g
Cd, Cu, Mn, Zn	0.1 µg/g
Cr, Ni	0.5 µg/g
Fe, Pb, Mo	1.0 µg/g
Mg	0.2 µg/g
Hg	0.005 µg/g

Since little or no contamination appears to be present due to the digestion process, corrections were not made to the data values reported by the laboratory.

3.1.1 ARSENIC

Data for the accuracy of the arsenic values reported in tissues have been plotted in Figure 2 (a). Four different types of tissues were used. These were dogfish muscle, dogfish liver, and lobster tissue from the National Research Council of Canada, and mussel tissue from the National Institute of Environmental Sciences (Japan). In terms of accuracy, arsenic values in tissues were generally within the certified range of values or ever so slightly below.

In terms of analytical precision as measured using duplicate analyses of different tissue samples from the surveys, values in excess of 2.0 µg/g were within 10 % of each other. Those less than 2.0 µg/g could be different from each other by 10 to 35 % (Figure 4 (a)). The maximum difference was reported for the duplicate analysis of a staghorn sculpin from Site B-9 which was reported by the laboratory to have a low level of contamination with sediment.

For accuracy of arsenic values in sediments, three different standard sediment types were analyzed. These were two types of marine sediments from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA). In terms of accuracy (Figure 3(a)), arsenic values in sediments were generally within the certified range of values or very slightly below. In terms of analytical precision as measured using duplicate analyses of different sediment samples from the surveys, values were generally within 10 % of each other.

Thus, these data indicate that the results reported here for arsenic are generally accurate and precise within 20 % for tissues and 10 % for sediments.

3.1.1.1 ARSENIC IN BENTHOS

Data for arsenic in soft-shelled clams from Sites B-1 and B-5 are in Table 1. The average of seven to five M. arenaria samples from each site were 2.77 µg/g and 1.48 µg/g (wet-weight), respectively. The high mean concentration was skewed by one sample with a 5.01 µg/g concentration;however, that particular sample had not been identified by the laboratory as containing sediment. Samples from Site B-5 were identified by the laboratory as containing from medium to high degree of sediment. One sample of horse clam (Tresus capex) from Site B-1 had a concentration of 1.19 µg/g, while a chiton (C. nuttallii) sample had 1.62 µg/g. Both these samples had a low level of sediment present which may have raised the concentration in the clams.

Crabs (C. magister) collected from Site B-9 had a mean concentration of 3.24 µg/g (Table 2), while those from Site B-10 had a mean concentration of 3.62 µg/g. The mean values for crabs from the two sites were not significantly different from each other (F-test; Student's "t" test: P=0.05). The crabs did not contain

quantities of sediment when analyzed. The Canadian Food and Drug Directorate (1979) have established a level of 3.5 µg/g arsenic (wet-weight) in fish protein to protect humans. Thus the crabs in Boundary Bay seem to be acceptable in this regard.

Mean values for arsenic in crabs (C. magister) from Burrard Inlet were from 13 to 64 µg/g (dry-weight) or about 2.6 to 12.8 µg/g (wet-weight). Thus arsenic values in crabs from Boundary Bay are low in comparison to Burrard Inlet.

3.1.1.2 ARSENIC IN FISH

Fish were collected from two sites: Site B-9 (Table 3) and B-10 (Table 4). The species from each site were different from each other, and thus comparisons between sites is not practical. The highest average arsenic concentrations were found in livers of starry flounders from Site B-10, at a mean concentration of 1.12 µg/g, although the mean concentration in muscle was about the same (1.02 µg/g, wet-weight). This is about four times higher than the mean values found in starry flounder tissue from the North and Main arms of the Fraser River in a 1988 survey (Swain and Walton, 1989). The Canadian Food and Drug Directorate (1979) have established a level of 3.5 µg/g arsenic (wet-weight) in fish protein to protect humans. Thus the fish from Boundary Bay seem to be acceptable in this regard.

A limited number of starry flounders from Burrard Inlet (Table 6) had concentrations from <4 to 24 µg/g (dry-weight), or about 1 to 4.8 µg/g expressed on a wet-weight basis. Thus arsenic in Boundary Bay fish muscle does not appear to be elevated.

Shiner perch from Site B-9 and Pacific sandab from Site B-10 were the only other species which were also analyzed in Burrard Inlet. The range of values for shiner perch from Boundary Bay (Table 3) were similar to those for Burrard Inlet (Table 6). The one Pacific sandab from Burrard Inlet (14 µg/g dry-weight or about 2.8 µg/g wet weight) was higher than found in Boundary Bay (0.62 to 0.67 µg/g - Table 4). Of interest is the fact that of all the species analyzed from both Boundary Bay sites, only starry flounders and buttersole from Site B-10 did not contain quantities of sediment.

3.1.1.3 ARSENIC IN SEDIMENTS

The highest arsenic values were obtained at Site B-10 (Table 7) near the International Boundary (10.1 µg/g mean value). Sediment from this site had the smallest particle size from any of the sites. These sediments would be expected to have the highest concentrations of metals, since they would have the largest surface area onto which the metals could be sorbed. This mean concentration is higher than found at Fraser River sites at about the same time (Swain and Walton, 1990). It is also higher than found in sediments collected from near the pump stations during this survey.

At the other sites adjacent to the pump stations, mean sediment arsenic concentrations were between 1.5 and 3.5 µg/g. These are lower than values found in the lower Fraser River at about the same time of year (Swain and Walton, 1990). The highest arsenic values found in ditches leading to the pump stations (Table 8) were at P-2 with a value of 8.68 µg/g.

The B.C. Ministry of Environment has established a Water Quality Objective for arsenic in sediments of Burrard Inlet of a maximum of 20 µg/g dry-weight (Nijman and Swain, 1990). Although not directly applicable to Boundary Bay, this Water Quality Objective is below the lowest Apparent Effects Threshold (AET) value established for Puget Sound sediments, and is a good reference for comparison. The AET corresponds to concentrations above which all samples were observed to have infaunal reductions relative to Puget Sound sediments. All Boundary Bay sediments had arsenic concentrations below the Water Quality Objective.

The highest arsenic concentration near the mouths of the three tributaries was at the mouth of the Serpentine River (Site B-6), with a mean value of 7.08 µg/g (Table 7). This site had the second highest percentage of fine particles associated with it, after the offshore site at the International Boundary. The site opposite the Little Campbell River had the coarsest sized particles, and also had the lowest mean arsenic concentration (1.5 µg/g ; Table 7). Samples collected in the mouths of the three tributaries themselves (Table 9) revealed that the highest arsenic value was associated with the Serpentine River, and the lowest with the Nicomekl River. The arsenic concentration in Little Campbell River sediments was 7.65 µg/g, nearly the same as found in the Serpentine River sample.

3.1.1.4 CONCLUSIONS

The results reported here for arsenic are generally accurate and precise within 20 % for tissues and 10 % for sediments. Mean arsenic concentrations were generally less than 2 µg/g for all benthic samples. Values in crab muscle were low in comparison to values recorded for Burrard Inlet, while those for fish were lower or similar to those from Burrard Inlet. Arsenic concentrations in both fish and crabs were below Food and Drug criteria for human consumption.

Sediment concentrations were lower at most sites than found in the Fraser River at the same time period. The highest arsenic values in sediments were for sites with the finest sized particles. The arsenic concentrations in the sediments were below the AET for Puget Sound, and therefore are not of concern.

3.1.2 CADMIUM

Data for the accuracy of the cadmium values reported in tissues have been plotted in Figure 2 (b). The four different types of reference tissues used for arsenic (Section 3.1.1) (dogfish muscle, dogfish liver, and lobster tissue from the National Research Council of Canada, and mussel tissue from the National Institute of Environmental Sciences (Japan)) were also used for cadmium. In terms of accuracy, cadmium values in tissues were generally within the certified range of values in the range from 0.07 to 0.1 µg/g and 3 to 5 µg/g, outside the range of values from 0.7 to 1.0 µg/g, and slightly lower than values greater than 20 µg/g (wet-weight).

In terms of analytical precision as measured using duplicate analyses of different tissue samples from the surveys, values in excess of 0.3 µg/g were within 15 % of each other. Those less than 0.3 µg/g could be different from each other by 15 to 30 % (Figure 4 (b)), although one difference of 175 % was noted at 0.12 µg/g level.

For accuracy of cadmium values in sediments, three different standard sediment types were analyzed as for arsenic (Section 3.1.1)(two types of marine sediments from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA)). In terms of accuracy (Figure 3(b)),

cadmium values in sediments were generally within the certified range of values or ever so slightly below. In terms of analytical precision as measured using duplicate analyses of different sediment samples from the surveys (Figure 5 (b)), values were generally within 10 % of each other at concentrations greater than 0.5 µg/g (dry-weight) and within 20 % of each other below this concentration.

Thus, these data indicate that the results reported here for cadmium are generally accurate for certain tissues in different ranges and precise within 10 to 20 % for all tissues. For sediments, the data were accurate and generally precise within 10 %.

3.1.2.1 CADMIUM IN BENTHOS

Data for cadmium in soft-shelled clams from Sites B-1 and B-5 are in Table 1. The average of seven to five M. arenaria samples from each site were 0.21 µg/g and 0.12 µg/g (wet-weight), respectively. Samples from Site B-5 were identified by the laboratory as containing from medium to high degree of sediment. One sample of horse clam (Tresus capex) from Site B-1 had a concentration of 0.23 µg/g, while a chiton (C. nuttallii) sample had 0.089 µg/g. Both these samples had a low level of sediment present which may have raised the concentration.

The mean concentration of cadmium in crabs (C. magister) was 0.175 µg/g at Site B-9 and 0.30 µg/g at Site B-10 (Table 2). There was significant variability for the mean values for crabs from the two sites (F-test: P=0.05). Crabs (C. magister) from Burrard Inlet had mean cadmium concentrations from <0.04 µg/g to 0.37 µg/g (dry-weight) (Table 5), or from below detection to about 0.08 µg/g (wet-weight). Thus crabs in Boundary Bay appear to be accumulating cadmium from some source in comparison to Burrard Inlet. Cadmium can be used as a fungicide, primarily for golf course greens (Adriano, 1986). Thus, cadmium may be entering Boundary Bay from the tributaries.

3.1.2.2 CADMIUM IN FISH

Of all the species analyzed from both sites in Boundary Bay, only starry flounders and buttersole from Site B-10 did not contain

quantities of sediment which could affect the values obtained for certain metals. At Site B-9, the mean concentrations for the whole fish were 0.015 µg/g for shiner perch, 0.039 µg/g for threespine stickleback, and 0.024 µg/g for staghorn sculpin (Table 3). Shiner perch (muscle tissue) from Burrard Inlet (Table 6) did not have detectable cadmium concentrations (<0.04 µg/g dry-weight or <0.008 µg/g wet-weight). At Site B-10, mean concentrations for the whole fish were 0.014 µg/g for snake prickleback, 0.009µg/g for buttersole, and 0.030 µg/g for Pacific sandab (Table 4). Pacific sandab (muscle tissue) from Burrard Inlet (Table 6) did not have detectable cadmium concentrations (<0.04 µg/g dry-weight or <0.008 µg/g wet-weight). The relatively higher values in whole fish from Boundary Bay compared to muscle samples from Burrard Inlet are likely due to mixing high liver concentrations with lower muscle concentrations.

The muscle for the starry flounder from Site B-10 had a mean cadmium concentration of 0.006 µg/g, which is less than was found in starry flounders near the mouth of the Fraser River in 1988. Starry flounders from the North Arm (n=3) had undetectable (<0.005 µg/g) cadmium concentrations, while those from the Main Arm had concentrations from <0.005 to 0.03 µg/g (mean value of 0.02 µg/g) (Swain and Walton, 1989). Starry flounders from Burrard Inlet had cadmium concentrations from <0.04 to 0.28 µg/g (dry-weight) or from <0.008 to 0.06 µg/g (wet-weight), higher than found in Boundary Bay. Cadmium concentrations in livers were a mean of 0.91 µg/g, considerably higher than found in the Fraser River (Swain and Walton 1989). Cadmium appears to be magnified in starry flounder livers over concentrations in muscle, as one would expect.

3.1.2.3 CADMIUM IN SEDIMENTS

As was the case for arsenic, the highest cadmium concentrations in sediments were at Site B-10 near the International Boundary with a value of 1.12 µg/g. At this site, the minimum value of 0.37 µg/g was higher than the maximum concentration for all other sites of 0.29 µg/g at Site B-2. Sediments collected in the ditch above the pump station which discharges near Site B-2 had the highest concentrations of any ditch samples: 1.45 µg/g cadmium (Table 8).

The B.C. Ministry of Environment has established a Water Quality Objective for cadmium in sediments of Burrard Inlet of a maximum of 1.0 µg/g cadmium (Nijman and Swain, 1990). Although not directly applicable to Boundary Bay, this Water Quality Objective is below the lowest AET value established for Puget Sound sediments of 5.8 µg/g (Tetra Tech, 1986), and is a good reference for comparison. Almost all Boundary Bay sediments had concentrations below this Objective.

Cadmium was detected at concentrations up to 0.40 µg/g in Fraser River sediments collected at about the same time (Swain and Walton, 1990). Thus, cadmium concentrations in sediments from the offshore site near the International Boundary are considerably higher than found in sediments from the Fraser River or elsewhere in Boundary Bay.

Cadmium concentrations associated with sediments from the mouths of the tributaries (Table 9) ranged from 0.29 µg/g in the Little Campbell River to 0.42 µg/g in the Serpentine River. These are similar to concentrations in the Fraser River sediments.

3.1.2.4 CONCLUSIONS

The data for precision and accuracy of cadmium measurements indicate that for certain tissues, the results reported here for cadmium are generally accurate in different ranges and precise within 10 to 20 % for all tissues. For sediments, the data were accurate and generally precise within 10 %.

Crabs in Boundary Bay have higher cadmium concentrations than those from Burrard Inlet, and appear to be accumulating cadmium from some source. Cadmium can be used as a fungicide, primarily for golf course greens. Thus, cadmium may be entering Boundary Bay from the tributaries where golf courses are located.

Cadmium concentrations in whole fish from Boundary Bay had considerably higher cadmium concentrations than tissue of fish of the same species from Burrard Inlet, possibly due to the livers. Cadmium concentrations in muscle from starry flounders from Boundary Bay were lower than found in starry flounders from either the Fraser River Estuary or Burrard Inlet. Cadmium appears to be magnified in starry flounder livers over concentrations in muscle.

Sediments collected at the offshore site near the International Boundary had cadmium concentrations higher than found in sediments from the Fraser River Estuary or other sites in Boundary Bay. All cadmium concentrations were below the lowest AET for Puget Sound, while most were below the Water Quality Objective for Burrard Inlet sediments of 1.0 µg/g.

3.1.3 CHROMIUM

Data for the accuracy of the chromium values reported in tissues have been plotted in Figure 2 (c). The four different types of tissues used for arsenic (Section 3.1.1) (dogfish muscle, dogfish liver, and lobster tissue from the National Research Council of Canada, and mussel tissue from the National Institute of Environmental Sciences (Japan)) were also used for chromium In terms of accuracy, chromium values in tissues were generally within the certified range of values or very close to the range.

In terms of analytical precision as measured using duplicate analyses of different tissue samples from the surveys, values in excess of 0.2 µg/g were within 5 % of each other. Those less than 0.2 µg/g could be different from each other by 5 to 160 % (Figure 4 (c)). However, most were within 20 % of each other.

For accuracy of chromium values in sediments, three different standard sediment types were analyzed (two types of marine sediments from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA)). In terms of accuracy (Figure 3(c)), chromium values in sediments were well outside and below the certified range of values by up to 50%. In terms of analytical precision as measured using duplicate analyses of different sediment samples from the surveys (Figure 5 (c)), values were generally within 10 % of each other at concentrations greater than 30 µg/g (dry-weight) and within 20 % of each other below this concentration.

Thus, these data indicate that the results reported here for chromium are generally accurate for all the tissues and precise within 10 to 20 % for most tissues. For sediments, the data were usually low and would not be considered to be accurate, but were

generally precise within 10 to 20 %, depending upon the concentration.

3.1.3.1 CHROMIUM IN BENTHOS

Data for chromium in soft-shelled clams from Sites B-1 and B-5 are in Table 1. The average of seven to five M. arenaria samples from each site were 0.32 µg/g and 0.50 µg/g (wet-weight), respectively. Samples from Site B-5 were identified by the laboratory as containing from medium to high degree of sediment. One sample of horse clam (Tresus capex) from Site B-1 had a concentration of 0.08 µg/g, while a chiton (C. nuttallii) sample had 0.45 µg/g. Both these samples had a low level of sediment present which may have raised the concentration.

The mean concentration of chromium in crabs (C. magister) was 0.035 µg/g at Site B-9 and 0.055 µg/g at Site B-10 (Table 2). The mean values for crabs from the two sites were not significantly different from each other (F-test; Student's "t" test: P=0.05). Mean chromium concentrations in crabs (C. magister) from Burrard Inlet were from 0.5 to 0.8 µg/g (dry-weight) (Table 5), or about 0.1 to 0.16 µg/g (wet-weight). Thus, chromium concentrations in crabs from Boundary Bay are low in comparison.

3.1.3.2 CHROMIUM IN FISH

Of all the species analyzed from both sites, only starry flounders and buttersole from Site B-10 did not contain quantities of sediment. At Site B-9, mean chromium concentrations were 0.15 µg/g for shiner perch, 0.16 µg/g for threespine stickleback, and 0.133 µg/g for staghorn sculpin (Table 3). Shiner perch from Burrard Inlet contained from 0.5 to 1.0 µg/g (dry-weight) chromium, or about 0.1 to 0.2 µg/g (wet-weight - Table 6). Fish from the Fraser River Estuary contained the following chromium concentrations: 1.1 to 1.41 µg/g in threespine stickleback and 0.03 to 0.07 µg/g (wet-weight) in staghorn sculpins (Swain and Walton, 1989).

At Site B-10, the mean chromium concentrations were as follows: 0.057 µg/g for snake prickleback, 0.116 µg/g for buttersole, 0.116 µg/g for Pacific sandab, and 0.068 µg/g for starry

flounder muscle and 0.035 µg/g for livers (Table 4). In Burrard Inlet, the sandab sole had 0.4 µg/g (dry-weight) (0.008 µg/g wet-weight) chromium and the starry flounder from 0.5 to 1.3 µg/g (dry-weight)(Table 6), or 0.1 to 0.26 µg/g (wet-weight). Starry flounders from the Fraser River Estuary had 0.55 to 2.5 µg/g chromium (Swain and Walton, 1989). Thus the fish from Boundary Bay had lower chromium concentrations than similar species from Burrard Inlet or the Fraser River Estuary, except for staghorn sculpins which were higher than in the Fraser River Estuary.

3.1.3.3 CHROMIUM IN SEDIMENTS

As stated in Section 3.1.3, chromium concentrations reported are likely low relative to the true values. No correction has been attempted to compensate for this factor. However, this should have no bearing on the validity of comparisons within this survey, or to those for the Fraser River collected at about the same time, and analyzed at the same laboratory using the same analytical techniques.

The highest chromium concentrations were found in sediments near the International Boundary at Site B-10 (Figure 6), with a maximum concentration of 58.1 µg/g (Table 7). This site had the smallest sized particles of any of the sites monitored for this study, which explains the high values found there.

The B.C. Ministry of Environment has established a Water Quality Objective for chromium in sediments of Burrard Inlet of a maximum of 60 µg/g chromium (Nijman and Swain, 1990). Although not directly applicable to Boundary Bay, this Water Quality Objective is above the lowest AET value established for Puget Sound sediments of 27 µg/g (Tetra Tech, 1986), and is a good reference for comparison. Almost all Boundary Bay sediments had concentrations below the Water Quality Objective, but several sites had maximum concentrations in excess of the AET.

Sediments from near the pump stations had average chromium values in the range from 18 to 25 µg/g (Table 7), while those from the ditches leading to the pump stations averaged about 34 µg/g chromium (Table 8).

The lowest chromium concentrations were for sediments from near the Little Campbell River (Site B-8 : Table 7), where average concentrations were 11.1 µg/g. Mean chromium concentrations near the mouths of the other two tributaries were 47.3 µg/g near the Serpentine River and 29.7 µg/g near the Nicomekl River. This shows that the tributaries can influence chromium concentrations in sediments near their confluence. This was also confirmed by the chromium concentrations in sediments from the mouths of the three tributaries, which were 42.8 µg/g in the Serpentine River, 40.4 µg/g for the Nicomekl River, and 47.3 µg/g for the Little Campbell River.

Samples collected from the mouth of the Fraser River at about the same time had concentrations of about 40 to 60 µg/g (Swain and Walton, 1990). Thus, chromium concentrations in sediments from most of the sites in Boundary Bay were lower than found in the Fraser River.

3.1.3.4 CONCLUSIONS

The data for accuracy and precision indicate that the results reported here for chromium are generally accurate for all the tissues and precise within 10 to 20 % for most tissues. For sediments, the data were usually low, but were generally precise within 10 to 20 %, depending upon the concentration.

Chromium concentrations in crabs from Boundary Bay are low in comparison to crabs collected from Burrard Inlet. Fish collected from Boundary Bay had similar or lower chromium concentrations in their whole body than similar species from Burrard Inlet or the Fraser River Estuary where only muscle tissue was analyzed. This was not the case for staghorn sculpins, which had higher concentrations than found in the same species from the Fraser River Estuary.

Chromium concentrations in sediments from most of the sites in Boundary Bay were lower than found in the Fraser River. At the two sites in Boundary Bay with the finest sized particles and highest metal concentrations, chromium levels were about the same as was found in the Fraser River. Sediment concentrations at some sites were above the lowest AET for Puget Sound, but concentrations at all sites were below the Objective established for sediments in Burrard Inlet.

3.1.4 COPPER

Data for the accuracy of the copper values reported in tissues have been plotted in Figure 2 (d). Four different types of tissues (dogfish muscle, dogfish liver, and lobster tissue from the National Research Council of Canada, and mussel tissue from the National Institute of Environmental Sciences (Japan)) were used to determine accuracy for copper. In terms of accuracy, copper values in tissues were generally within the certified range of values or very close to the range for values less than 6 µg/g but below the certified range for values in excess of 18 µg/g.

In terms of analytical precision as measured using duplicate analyses of different tissue samples from the surveys, values in excess of 5 µg/g were within about 5 % of each other. Those less than 5 µg/g could be different from each other by 5 to 80 % (Figure 4 (d)). However, most were within 25 % of each other.

For accuracy of copper values in sediments, three different standard sediment types were analyzed (two types of marine sediments from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA)). In terms of accuracy (Figure 3(d)), copper values in sediments were within the certified range of values. In terms of analytical precision as measured using duplicate analyses of different sediment samples from the surveys (Figure 5 (d)), values were generally within 15 % of each other at all concentrations.

Thus, these data indicate that the results reported here for copper are generally accurate for all the tissues at lower concentrations but low at higher concentrations, thus underestimating real levels. They are precise to within 10 to 25 % for most tissues. For sediments, the data were within the certified range of values and would be considered to be accurate. They were generally precise within 15 %, depending upon the concentration.

3.1.4.1 COPPER IN BENTHOS

Data for copper in soft-shelled clams from Sites B-1 and B-5 are in Table 1. The average of seven to five M. arenaria samples from each site were 1.71 µg/g and 1.84 µg/g (wet-weight),

respectively. Samples from Site B-5 were identified by the laboratory as containing from medium to high degree of sediment. One sample of horse clam (Tresus capex) from Site B-1 had a concentration of 2.07 µg/g, while a chiton (C. nuttallii) sample had 0.67 µg/g. Both these samples had a low level of sediment present which may have raised the concentration.

The mean concentration of copper in crabs (C. magister) was 9.25 µg/g at Site B-9 and 25.7 µg/g at Site B-10 (Table 2). There was significant variability for the mean values for crabs from the two sites (F-test: P=0.05). All concentrations were well below the former Canadian Food and Drug Act Regulation value (now repealed) of 100 µg/g to protect human health. It should be remembered that the accuracy data cited in Section 3.1.4 showed that reported concentrations greater than 18 µg/g are likely lower than true values, while those below this concentration are accurate.

Crabs (C. magister) from Burrard Inlet had mean concentrations from 29 to 75.9 µg/g (dry-weight) (Table 5), or about 6 to 15 µg/g (wet-weight). Higher values of copper can be expected in Boundary Bay due to the possible use of copper in fertilizers, bactericides, fungicides, and as a feed additive (Adriano, 1986).

3.1.4.2 COPPER IN FISH

Of all the species analyzed from both sites, only starry flounders and buttersole from Site B-10 did not contain quantities of sediment. At Site B-9, the mean copper concentrations were 0.80 µg/g for shiner perch, 1.84 µg/g for threespine stickleback, and 1.0 µg/g for staghorn sculpins. In Burrard Inlet, shiner perch had concentrations from 1.5 to 3.9 µg/g copper on a dry-weight basis or 0.3 to 0.78 µg/g wet-weight (Table 6). Fish from the Fraser River Estuary contained 1.44 to 1.58 µg/g copper (threespine stickleback) and 0.27 to 0.79 µg/g copper (staghorn sculpin).

At Site B-10, mean copper concentrations were 0.85 µg/g for snake prickleback, 0.65 µg/g for buttersole, 0.77 µg/g for Pacific sandab, and 0.37 µg/g for muscle of starry flounder but 5.61 µg/g in starry flounder livers (Table 4). Copper appears to be magnified in starry flounder livers over concentrations in muscle. Copper could not be detected in the one muscle tissue from Pacific sandab from Burrard Inlet (<0.008 µg/g), but ranged from <0.4 to 4.0 µg/g (dry-

weight) (<0.008 to 0.8 µg/g wet-weight) in starry flounders (Table 6). Starry flounders from the Fraser River Estuary contained 0.26 to 1.17 µg/g copper in muscle and from 4.9 to 9.7 µg/g in livers (Swain and Walton, 1989). Thus, starry flounders from Boundary Bay have similar copper concentrations to those found in starry flounders in the Fraser River Estuary and Burrard Inlet.

3.1.4.3 COPPER IN SEDIMENTS

As was the case with the other metals, the highest copper values were found at Site B-10 near the International Boundary (Figure 6), with a mean value of 39.9 µg/g but a maximum of only 41.9 µg/g (Table 7). This was the site with the finest sized sediments. The mean copper concentration at most of the other sites was from about 3 to 10 µg/g.

The B.C. Ministry of Environment has established a Water Quality Objective for copper in sediments of Burrard Inlet of a maximum of 100 µg/g cadmium (Nijman and Swain, 1990). Although not directly applicable to Boundary Bay, this Water Quality Objective is below the lowest AET value established for Puget Sound sediments of 310 µg/g (Tetra Tech, 1986), and is a good reference for comparison. All Boundary Bay sediments had concentrations below this Objective.

The mean copper value of 26.6 µg/g from Site B-6 was the highest value for sediments from sites collected near the tributaries. Copper concentrations in sediments from the mouths of the tributaries were usually higher, with concentrations of (Table 9) 32.1 µg/g in the Serpentine River, 21.8 µg/g in the Nicomekl River, and 27.3 µg/g in the Little Campbell River.

Copper concentrations in samples collected from the Fraser River at about the same time period were in the order of 40 to 60 µg/g (Swain and Walton, 1990). Thus, copper concentrations in sediments from Boundary Bay are slightly lower than found in similar sized sediments from the Fraser River.

Mean concentrations from near the pump stations were from 4.27 to 8.04 µg/g (Table 7). Concentrations in sediments from ditches above the pump stations ranged from 18.6 to 72.7 µg/g. This indicates that the ditches are a possible source of copper to the Bay.

3.1.4.4 CONCLUSIONS

The results reported for copper are generally accurate for all the tissues at lower concentrations but low at higher concentrations, thus underestimating real levels. They are precise to within 10 to 25 % for most tissues. For sediments, the data were within the certified range of values and would be considered to be accurate. They were generally precise within 15 %, depending upon the concentration.

Higher values of copper can be expected and were found in crabs from Boundary Bay compared to crabs from Burrard Inlet. Generally, it appears that copper concentrations are similar or higher in Boundary Bay fish than in fish of the same species in Burrard Inlet or the Fraser River. Copper appears to be magnified in starry flounder livers over concentrations in muscle. The higher levels are likely due to the possible use of copper in fertilizers, bactericides, fungicides, and as a feed additive.

Higher concentrations of copper were found in sediments collected above the five pump stations than were found in sediments from many of the sites in Boundary Bay. This indicates that the ditches are a possible source of copper to the Bay.

Copper concentrations in sediments from Boundary Bay were slightly lower than found in similar sized sediments from the Fraser River. The copper concentrations were below the Water Quality Objective for Burrard Inlet and the AET for Puget Sound.

3.1.5 LEAD

Data for the accuracy of the lead values reported in tissues have been plotted in Figure 2 (f). Four different types of tissues (dogfish muscle, dogfish liver, and lobster tissue from the National Research Council of Canada, and mussel tissue from the National Institute of Environmental Sciences (Japan)) were used for lead. In terms of accuracy, lead values in tissues were generally within the certified range of values or very close to the range.

In terms of analytical precision as measured using duplicate analyses of different tissue samples from the surveys, values in

excess of 0.04 µg/g were within about 5 % of each other. Those less than 0.04 µg/g could be different from each other by 5 to 65 % (Figure 4 (f)). However, most were within 30 % of each other.

For accuracy of lead values in sediments, three different standard sediment types were analyzed (two types of marine sediments from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA)). In terms of accuracy (Figure 3(f)), lead values in sediments were within the certified range of values for most of the reference sediments but slightly lower than the certified range for the estuarine reference sediment. In terms of analytical precision as measured using duplicate analyses of different sediment samples from the surveys (Figure 5 (f)), values were generally within 15 % of each other at all concentrations.

Thus, these data indicate that the results reported here for lead are generally accurate for all the tissues. They are precise to within 30 % for most tissues. For sediments, the data were within the certified range of values except for the estuarine reference sample. They were generally precise within 15 %, depending upon the concentration.

3.1.5.1 LEAD IN BENTHOS

Data for lead in soft-shelled clams from Sites B-1 and B-5 are in Table 1. The average of seven to five M. arenaria samples from each site were 0.019 µg/g and 0.101 µg/g (wet-weight), respectively. Samples from Site B-5 were identified by the laboratory as containing from medium to high degree of sediment, which may explain in part the considerably higher concentrations at this site. One sample of horse clam (Tresus capex) from Site B-1 had a concentration of 0.019 µg/g, while a chiton (C. nuttallii) sample had 0.067 µg/g. Both these samples had a low level of sediment present which may have raised the concentration.

The mean concentration of lead in crabs (C. magister) was 0.014 µg/g at Site B-9 and 0.031 µg/g at Site B-10 (Table 2). There was significant variability for the mean values for crabs from the two sites (F-test: P=0.05). These concentrations are well below the B.C. Environment alert level of 0.8 µg/g (Nagpal, 1987).

Crabs (C. magister) from Burrard Inlet contained mean lead concentrations from 0.12 to 1.81 µg/g (dry-weight)(Table 5), or from 0.024 to 0.36 µg/g (wet-weight). Thus, the lead concentrations are considerably lower in crabs from Boundary Bay than in those from Burrard Inlet. However, lead concentrations in crabs from Burrard Inlet do appear to be affected by the season of the year, with considerably higher concentrations during the winter months (Table 5). Presumably, this reflects the discharge of stormwater runoff. If data for the winter period are excluded and only data for crabs collected in October 1985 are used, the mean concentrations in crabs from Burrard Inlet were from 0.18 to 0.19 µg/g (dry-weight), or about 0.036 µg/g (wet-weight). This is similar in magnitude to concentrations found in Boundary Bay crabs.

3.1.5.2 LEAD IN FISH

Of all the species analyzed from both sites, only starry flounders and buttersole from Site B-10 did not contain quantities of sediment. The mean lead concentration for both shiner perch and staghorn sculpin was 0.015 µg/g at Site B-9, while the mean concentration for threespine stickleback was 0.026 µg/g (Table 3). Shiner perch from Burrard Inlet (Table 6) had non-detectable lead concentrations (<0.08 µg/g dry-weight or <0.016 µg/g wet-weight). Threespine stickleback from the Fraser River Estuary contained 0.04 and 0.05 µg/g lead, while staghorn sculpins had 0.01 to 0.07 µg/g (Swain and Walton, 1989).

Mean lead concentrations in fish from Site B-10 (Table 4) were 0.044 µg/g for snake prickleback, 0.063 µg/g for buttersole, 0.057 µg/g for Pacific sandab, and 0.022 µg/g for starry flounder muscle and 0.12 µg/g for livers (Table 4). Lead appears to be magnified in starry flounder livers over concentrations in muscle. In Burrard Inlet, the Pacific sandab (Table 6) had undetectable lead values (0.016 µg/g), while starry flounder concentrations ranged from <0.08 to 1.43 µg/g (dry-weight) or <0.016 to 0.28 µg/g (wet-weight). Starry flounders from the Fraser River Estuary had 0.02 to 0.08 µg/g lead.

The B.C Ministry of Environment have established an alert level of 0.8 µg/g (wet-weight) in the edible portions of fish/shellfish (Nagpal, 1987). The maximum concentrations in all the fish sampled, both whole fish and muscle, were well below this alert

level. Thus lead concentrations in fish from Boundary Bay are not a concern from a human health perspective, and are lower than those from Burrard Inlet or the Fraser River Estuary.

3.1.5.3 LEAD IN SEDIMENTS

As was the case with the other metals, the highest lead concentrations were measured at Site B-10 (Figure 6), with a maximum concentration of 18.6 µg/g (Table 7). Values nearly as high were also measured at Site B-6 opposite the mouth of the Serpentine River, as has been found for other metals. Mean concentrations at the other sites were between 1.7 and 4.5 µg/g, indicating low lead concentrations in sediments from other areas of Boundary Bay.

The B.C. Ministry of Environment has established a Water Quality Objective for lead in sediments of Burrard Inlet of a maximum of 30 µg/g lead (Nijman and Swain, 1990). Although not directly applicable to Boundary Bay, this Water Quality Objective is below the lowest AET of 300 µg/g established for Puget Sound sediments (Tetra Tech, 1986), and is a good reference for comparison. All Boundary Bay sediments had concentrations below this Water Quality Objective and the Puget Sound AET.

Sediment samples collected from the mouths of the three tributaries had lead concentrations of 42.1 µg/g in the Serpentine River, but only 16.6 µg/g in the Nicomekl River, and 12.2 µg/g in the Little Campbell River (Table 9). These data indicate that the Serpentine and Nicomekl rivers are contributing appreciable quantities of lead to Boundary Bay sediments.

Values measured in a survey of sediments in the Fraser River Estuary near the mouths of the North and Main arms were from 21.3 to 24 µg/g and 9.6 to 12.4 µg/g, respectively (Swain and Walton, 1990). Thus, lead concentrations in the finer grain size particles from Boundary Bay are similar to those from the Fraser River Estuary.

Sediments collected in the ditches above the five pump stations contained 12.9 to 81.8 µg/g of lead (Table 8). The maximum concentration was in the ditch leading to the pump station opposite Site B-2. These data indicate that some of the pump stations are

contributing appreciable quantities of lead to Boundary Bay sediments.

3.1.5.4 CONCLUSIONS

The results reported here for lead are generally accurate for all the tissues. They are precise to within 30 % for most tissues. For sediments, the data were within the certified range of values except for the estuarine reference sample. They were generally precise within 15 %, depending upon the concentration.

Concentrations of lead measured in crabs and fish were well below the alert level of 0.8 µg/g. Lead concentrations were considerably lower in crabs from Boundary Bay than in those from Burrard Inlet. However, lead concentrations in crabs from Burrard Inlet appear to be affected by the season of the year, and once those crabs collected from Burrard Inlet during the winter are excluded, lead concentrations appear to be similar.

Lead concentrations in fish from Boundary Bay are lower than those from Burrard Inlet or the Fraser River Estuary. Lead appears to be magnified in starry flounder livers versus muscle concentrations. Lead concentrations in the finer grain size particles from Boundary Bay were similar to those from the Fraser River Estuary, while those from the other sites were considerably lower.

Lead concentrations in Boundary Bay sediments were usually highest at sites near the tributaries. It is suspected that some of the pump stations, as well as the Serpentine and Nicomekl rivers, are contributing considerable quantities of lead to Boundary Bay. All lead concentrations in sediments from Boundary Bay were below the Water Quality Objective for Burrard Inlet and the lowest AET for Puget Sound, and are therefore not a concern.

3.1.6 MERCURY

Data for the accuracy of the mercury values reported in tissues have been plotted in Figure 2 (i). Four different types of tissues (dogfish muscle, dogfish liver, and lobster tissue from the National Research Council of Canada, and mussel tissue from the National Institute of Environmental Sciences (Japan)) were also used

for mercury. In terms of accuracy, mercury values in tissues were generally within the certified range of values or very close to the range.

In terms of analytical precision as measured using duplicate analyses of different tissue samples from the surveys, values in excess of 0.02 µg/g were within about 20 % of each other. Those less than 0.02 µg/g could be different from each other by 35 to 80 % (Figure 4 (i)). However, most were still within 20 % of each other.

For accuracy of mercury values in sediments, three different standard sediment types were analyzed (two types of marine sediments from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA)). In terms of accuracy (Figure 3(i)), mercury values in sediments were within the certified range of values or higher for the reference sediments. In terms of analytical precision as measured using duplicate analyses of different sediment samples from the surveys (Figure 5 (i)), values were generally within 20 % of each other at all concentrations.

Thus, these data indicate that the results reported here for mercury are generally accurate for all the tissues. They are precise to within 20 % for most tissues. For sediments, the data were within the certified range of values or higher than the range. They also were generally precise within 20 %.

3.1.6.1 MERCURY IN BENTHOS

Data for mercury in soft-shelled clams from Sites B-1 and B-5 are in Table 1. The average of seven to five M. arenaria samples from each site were 0.007 µg/g and 0.018 µg/g (wet-weight), respectively. Samples from Site B-5 were identified by the laboratory as containing from medium to high degree of sediment. One sample of horse clam (Tresus capex) from Site B-1 had a concentration of 0.016 µg/g, while a chiton (C. nuttallii) sample had <0.005 µg/g. Both these samples had a low level of sediment present which may have raised the concentration.

The mean concentration of mercury in crabs (C. magister) was 0.053 µg/g at Site B-9 and 0.049 µg/g at Site B-10 (Table 2). There was significant variability for the mean values for crabs from the

two sites (F-test: P=0.05). At these mean concentrations, an individual could consume continuously over 2 000 grams of crab muscle per week (B.C. Ministry of Environment, 1989). Crabs (C. magister) from Burrard Inlet contained mean concentrations from 0.15 to 1.28 µg/g (dry-weight) (Table 5), or about 0.03 to 0.26 µg/g (wet-weight). Mercury concentrations in Boundary Bay are similar or lower than found in Burrard Inlet.

3.1.6.2 MERCURY IN FISH

Of all the species analyzed from both sites, only starry flounders and buttersole from Site B-10 did not contain quantities of sediment. At Site B-9, mean concentrations of mercury were 0.005 µg/g in shiner perch, 0.023 µg/g in threespine stickleback, and 0.008 µg/g in staghorn sculpin (Table 3). No comparable species were collected from Burrard Inlet (Table 6). In the Fraser River Estuary, mercury concentrations ranged from 0.04 to 0.14 µg/g for staghorn sculpin, while both threespine sticklebacks collected had concentrations of 0.03 µg/g. The B.C. Ministry of Environment have established criteria for mercury concentrations in the edible portion of fish or shellfish ranging from 0.1 to 0.5 µg/g, depending on the weekly consumption rate (B.C. Ministry of Environment, 1989). All the mercury concentrations in Boundary Bay fish were well below this lowest criterion.

This was also the case for mercury concentrations in fish collected from Site B-10 (Table 4), where mean concentrations were 0.013 µg/g for snake prickleback, 0.010 µg/g for buttersole, 0.013 µg/g for Pacific sandab, and 0.054 µg/g for starry flounder muscle and 0.05 µg/g for livers. One starry flounder had concentrations approaching the lowest criterion. Starry flounders from Burrard Inlet had values from 0.2 to 1.49 µg/g (dry-weight, Table 6), or about 0.04 to 0.3 µg/g (wet-weight). Starry flounders from the Fraser River Estuary occasionally exceeded the lowest criterion, with concentrations from 0.02 to 0.13 µg/g (Swain and Walton, 1989).

Thus concentrations in fish from Boundary Bay were below criteria for human consumption and lower than levels in fish from the Fraser River Estuary and Burrard Inlet.

3.1.6.3 MERCURY IN SEDIMENTS

From Section 3.1.6, it should be remembered that the values cited here may be slightly higher than the true value. This will have no bearing on comparisons among sites, or on comparisons to values in sediments from the Fraser River collected at about the same time and analyzed at the same analytical laboratory. No corrections have been applied to the data reported here to compensate for this factor.

Mercury concentrations in sediments were highest at Site B-10 at the International Boundary (Figure 6), with a maximum value of 0.095 µg/g and a mean concentration of 0.078 µg/g (Table 7). At most other sites, the mean concentration ranged between 0.01 and 0.02 µg/g. As was the case for the other metals discussed, the mean mercury concentration at Site B-6 was intermediate, at 0.049 µg/g.

The B.C. Ministry of Environment has established a Water Quality Objective for mercury in sediments of Burrard Inlet of a maximum of 0.15 µg/g mercury (Nijman and Swain, 1990). Although not directly applicable to Boundary Bay, this Water Quality Objective is below the lowest AET value established for Puget Sound sediments of 0.41 µg/g (Tetra Tech, 1986), and is a good reference for comparison. All Boundary Bay sediments had concentrations below the Water Quality Objective and the AET for Puget Sound.

Mercury concentrations in the Fraser River Estuary sediments which were collected at about the same time as those from Boundary Bay and were analyzed at the same laboratory ranged from 0.077 to 0.091 µg/g at the mouth of the North Arm and from 0.056 to 0.069 µg/g at the mouth of the Main Arm (Swain and Walton, 1990). Thus, mercury concentrations in sediments from most sites in Boundary Bay are low in comparison to sediments from the Fraser River Estuary.

Sediments collected from the ditches leading to the pump stations contained from 0.016 to 0.069 µg/g mercury (Table 8). This indicates that at some sites, the pump stations could be sources of mercury to Boundary Bay.

Mercury concentrations in sediments from the mouths of the three tributaries (Table 9) were as follows: 0.044 µg/g in the Serpentine River, 0.033 µg/g in the Nicomekl River, and 0.037 µg/g

in the Little Campbell River. These values are slightly higher than the mean concentrations at most sites in Boundary Bay, implying that these tributaries are contributors of mercury to Boundary Bay.

3.1.6.4 CONCLUSIONS

The results reported for mercury are generally accurate for all the tissues and are precise to within 20 % for most tissues. For sediments, the data were within the certified range of values or higher than the range. They also were generally precise within 20 %.

Mercury concentrations in Boundary Bay are similar or lower than found in Burrard Inlet. These levels are well within the maximum allowable for human consumption for most individuals. Mercury concentrations in fish from Boundary Bay were below criteria for human consumption and lower than levels in fish from the Fraser River Estuary or Burrard Inlet.

Mercury concentrations in sediments from most sites in Boundary Bay were low in comparison to sediments from the Fraser River Estuary. At some sites in Boundary Bay, the pump stations and the tributaries could be sources of mercury to the Bay. Sediment mercury concentrations were all below the Water Quality Objective for Burrard Inlet and the lowest AET for Puget Sound.

3.1.7 NICKEL

Data for the accuracy of the nickel values reported in tissues have been plotted in Figure 2 (k). Four different types of tissues (dogfish muscle, dogfish liver, and lobster tissue from the National Research Council of Canada, and mussel tissue from the National Institute of Environmental Sciences (Japan)) were also used for nickel. In terms of accuracy, nickel values in tissues were generally within the certified range of values or very close to the range.

In terms of analytical precision as measured using duplicate analyses of different tissue samples from the surveys, values in excess of 0.3 µg/g were within about 20 % of each other. Those less than 0.3 µg/g could be different from each other by 25 to 70 % (Figure 4 (k)). However, virtually all the duplicates at all concentrations were within 20 % of each other.

For accuracy of nickel values in sediments, three different standard sediment types (two types of marine sediments from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA)) were used. In terms of accuracy (Figure 3(k), nickel values in sediments were below the certified range of values for the reference sediments. In terms of analytical precision as measured using duplicate analyses of different sediment samples from the surveys (Figure 5 (k)), values were generally within 10 % of each other at all concentrations.

Thus, these data indicate that the results reported here for nickel are generally accurate for all the tissues. They are precise to within 20 % for most tissues. For sediments, the data were below the certified range of values. They were generally precise within 10 %.

3.1.7.1 NICKEL IN BENTHOS

Data for nickel in soft-shelled clams from Sites B-1 and B-5 are in Table 1. The average of seven to five M. arenaria samples from each site were 0.55 µg/g and 0.64 µg/g (wet-weight), respectively. Samples from Site B-5 were identified by the laboratory as containing from medium to high degree of sediment. One sample of horse clam (Tresus capex) from Site B-1 had a concentration of 0.10 µg/g, while a chiton (C. nuttallii) sample had 0.97 µg/g. Both these samples had a low level of sediment present which may have raised the concentration.

The mean concentration of nickel in crabs (C. magister) was 0.064 µg/g at Site B-9 and 0.21 µg/g at Site B-10 (Table 2). There was significant variability for the mean values for crabs from the two sites (F-test: P=0.05). Nickel was generally not detected (<2 µg/g dry-weight or <0.4 µg/g wet-weight) in crabs (C. magister) from Burrard Inlet (Table 5) because a higher detection limit was used.

3.1.7.2 NICKEL IN FISH

Of all the species analyzed from both sites, only starry flounder and buttersole from Site B-10 did not contain quantities of

sediment. Mean nickel concentrations were 0.112 µg/g in shiner perch, 0.13 µg/g in threespine stickleback, and 0.084 µg/g in staghorn sculpin from Site B-9 (Table 3) and 0.099 µg/g in snake prickleback, 0.111 µg/g in buttersole, 0.134 µg/g in Pacific sandab, and 0.06 µg/g in starry flounder muscle and 0.16 µg/g in starry flounder livers from Site B-10 (Table 4). Nickel appears to be magnified in starry flounder livers over concentrations in muscle.

All fish except one from Burrard Inlet were below the detection limit of 2 µg/g (Table 6) dry-weight or 0.4 µg/g wet-weight. The one exception was a 0.4 µg/g nickel concentration. In the Fraser River Estuary, values ranged from 0.1 to 2.67 µg/g in starry flounder, 0.05 to 0.96 µg/g in staghorn sculpin, and 2.2 to 2.63 µg/g in threespine stickleback (Swain and Walton, 1989). Thus the fish from Boundary Bay have low nickel concentrations relative to similar species from the Fraser River Estuary or Burrard Inlet.

3.1.7.3 NICKEL IN SEDIMENTS

From Section 3.1.7, it should be remembered that the values cited here may be slightly lower than the true value. This will have no bearing on comparisons among sites, or on comparisons to values in sediments from the Fraser River collected at about the same time and analyzed at the same analytical laboratory. No corrections have been applied to the data reported here to compensate for this factor.

Nickel concentrations at Site B-10 were the highest for all the sites sampled, with concentrations from 38 to 40.9 µg/g (Table 7). Sediments from Site B-6 were almost as high, with concentrations from 30.1 to 36.4 µg/g. Interestingly, the lowest nickel concentrations were found in sediments from Site B-8 at the mouth of the Little Campbell River, where nickel concentrations ranged from 6.27 to 8.16 µg/g. Values at the other sites were generally in a range from 12 to 22 µg/g.

The B.C. Ministry of Environment has established a Water Quality Objective for nickel in sediments of Burrard Inlet of a maximum of 45 µg/g nickel (Nijman and Swain, 1990). Although not directly applicable to Boundary Bay, this Water Quality Objective is above the lowest AET value established for Puget Sound sediments of 28 µg/g (Tetra Tech, 1986), and is a good reference for comparison. All Boundary Bay sediments had nickel concentrations

below the Water Quality Objective, while many of the sites had concentrations below the lowest AET for Puget Sound.

Samples collected from the mouths of the three tributaries had concentrations as follows: 39.2 µg/g in the Serpentine River, 34.1 µg/g in the Nicomekl River, and 36.3 µg/g in the Little Campbell River (Table 9). Sediments collected in ditches leading to the pump stations had nickel concentrations from 28.7 to 64.9 µg/g (Table 8). Thus the pump stations and the tributaries can be net contributors of nickel to Boundary Bay sediments.

Sediments from the Fraser River Estuary had nickel concentrations from 52.3 to 55.2 µg/g in the North Arm near the mouth and from 46.9 to 51.8 µg/g in the Main Arm near the mouth (Swain and Walton, 1990). Thus all concentrations of nickel in sediments from Boundary Bay were less than those found in the Fraser River Estuary.

3.1.7.4 CONCLUSIONS

The results reported for nickel are generally accurate for all the tissues and are precise to within 20 % for most tissues. For sediments, the data were below the certified range of values. They were generally precise within 10 %.

The fish from Boundary Bay had low nickel concentrations relative to similar species from the Fraser River Estuary or Burrard Inlet. The detection limit for crabs from Burrard Inlet was too high to allow a meaningful comparison to the data from Boundary Bay. Nickel appears to be magnified in starry flounder livers over concentrations in muscle.

All nickel concentrations in sediments from Boundary Bay were less than those found in the Fraser River Estuary, and below the Water Quality Objective for Burrard Inlet. Most nickel concentrations were below the lowest AET values established for Puget Sound.

3.1.8 ZINC

Data for the accuracy of the zinc values reported in tissues have been plotted in Figure 2 (l). Four different types of tissues were used (dogfish muscle, dogfish liver, and lobster tissue from the National Research Council of Canada, and mussel tissue from the

National Institute of Environmental Sciences (Japan)) for zinc. In terms of accuracy, zinc values in tissues were generally within the certified range of values or very close to the range.

In terms of analytical precision as measured using duplicate analyses of different tissue samples from the surveys, all values except one were within about 20 % of each other (Figure 4 (l)). There is no explanation for the apparent anomaly which was for a staghorn sculpin.

For accuracy of zinc values in sediments, three different standard sediment types were analyzed as for arsenic (Section 3.1.1)(two types of marine sediments from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA)). In terms of accuracy (Figure 3(l), zinc values in sediments were within or just slightly below the certified range of values for the reference sediments. In terms of analytical precision as measured using duplicate analyses of different sediment samples from the surveys (Figure 5 (l)), values were generally within 15 % and usually less than 10 % of each other at all concentrations.

Thus, these data indicate that the results reported here for zinc are generally accurate for all the tissues. They are precise to within 20 % for most tissues. For sediments, the data were within or slightly below the certified range of values. They were generally precise within 10 %.

3.1.8.1 ZINC IN BENTHOS

Data for zinc in soft-shelled clams from Sites B-1 and B-5 are in Table 1. The average of seven to five M. arenaria samples from each site were 11.5 µg/g and 11.9 µg/g (wet-weight), respectively. Samples from Site B-5 were identified by the laboratory as containing from medium to high degree of sediment. One sample of horse clam (Tresus capex) from Site B-1 had a concentration of 10.7 µg/g, while a chiton (C. nuttallii) sample had 14.0 µg/g. Both these samples had a low level of sediment present which may have raised the concentration.

The mean concentration of zinc in crabs (C. magister) was 43.5 µg/g at Site B-9 and 34.5 µg/g at Site B-10 (Table 2). There was

significant variability for the mean values for crabs from the two sites (F-test: P=0.05). Crabs (C. magister) from Burrard Inlet had mean zinc concentrations from 147.5 to 233 µg/g (dry-weight) or 29.5 to 46.6 µg/g (wet-weight). Thus, zinc concentrations are similar in crabs from both areas.

3.1.8.2 ZINC IN FISH

Of all the species analyzed from both sites, only starry flounders and buttersole from Site B-10 did not contain quantities of sediment. Mean concentrations were 17.9 µg/g for shiner perch, 40.1 µg/g for threespine stickleback, and 13.6 µg/g for staghorn sculpin at Site B-9 (Table 3), while at Site B-10, mean concentrations were 17.6 µg/g in snake prickleback, 12.2 µg/g in buttersole, 16.6 µg/g in Pacific sandab, and 11.0 µg/g in muscle and 28.5 µg/g in livers of starry flounders (Table 4). Zinc appears to be magnified in starry flounder livers over concentrations in muscle.

Concentrations in fish from Burrard Inlet (Table 6) were 13.1 µg/g (dry-weight) in sandab sole (≈ 2.6 µg/g wet-weight), 19.3 to 26.4 µg/g (dry-weight) in shiner perch (≈ 3.8 to 5.3 µg/g wet-weight), and from 17.1 to 64.7 µg/g (dry-weight) in starry flounders (≈ 3.4 to 12.9 µg/g wet-weight). Fish collected in 1988 from the Fraser River Estuary had the following ranges of zinc concentrations: 4.4 to 8.0 µg/g for staghorn sculpin, 8.9 to 26.9 µg/g for starry flounder, and 29.6 to 33.5 µg/g for threespine stickleback (Swain and Walton, 1989).

The staghorn sculpins and shiner perch collected from Boundary Bay appear to have higher, while starry flounders appear to have lower zinc concentrations than those same species from the Fraser River Estuary or Burrard Inlet.

3.1.8.3 ZINC IN SEDIMENTS

As was the case for nickel, zinc concentrations in sediments from Sites B-10 and B-6 were similar (Figure 6), with a range of values from 102 to 110 µg/g and 87 to 107 µg/g, respectively (Table 7). The lowest values were in sediments from Site B-8 near the mouth of the Little Campbell River, with a range from 16.3 to

21.2 µg/g, although not appreciably lower than at other sites. At the other sites, concentrations were between about 20 and 55 µg/g.

The B.C. Ministry of Environment has established a Water Quality Objective for zinc in sediments of Burrard Inlet of a maximum of 150 µg/g zinc (Nijman and Swain, 1990). Although not directly applicable to Boundary Bay, this Water Quality Objective is below the lowest AET value established for Puget Sound sediments of 260 µg/g (Tetra Tech, 1986), and is a good reference for comparison. All Boundary Bay sediments had concentrations below the Water Quality Objective for Burrard Inlet and the lowest AET for Puget Sound.

Zinc concentrations in sediments from the mouths of the three tributaries (Table 9) were as follows: 114 µg/g in the Serpentine River, 92.2 µg/g in the Nicomekl River, and 84.7 µg/g in the Little Campbell River. Sediments collected in ditches leading to the pump stations had zinc concentrations from 62.6 to 173 µg/g (Table 8). These data indicate that the tributaries and pump stations are net contributors of zinc to Boundary Bay.

Sediments were collected at about the same time from the Fraser River Estuary and analyzed at the same laboratory (Swain and Walton, 1990). Zinc concentrations in sediments from the mouths of the North and Main arms were from 133 to 139 µg/g and 97.9 to 107 µg/g, respectively. Thus zinc concentrations in Boundary Bay sediments were about the same as found in the Fraser River at sites with approximately the same sized sediments.

3.1.8.4 CONCLUSIONS

The results reported for zinc are generally accurate for all the tissues and are precise to within 20 % for most tissues. For sediments, the data were within or slightly below the certified range of values. They were generally precise to within 10 %.

Crabs (C. magister) collected from Boundary Bay and Burrard Inlet had similar zinc concentrations. Staghorn sculpins and shiner perch collected from Boundary Bay appeared to have higher zinc concentrations than those from the Fraser River Estuary or Burrard Inlet, while starry flounders had lower concentrations. Zinc appears

to be magnified in starry flounder livers over concentrations in muscle.

Zinc concentrations in Boundary Bay sediments were about the same as found in the Fraser River at sites with approximately the same sized sediments. Zinc concentrations in Boundary Bay sediments were below the Water Quality Objective for Burrard Inlet and the lowest AET for Puget Sound. The tributaries and pump stations appear to be net contributors of zinc to Boundary Bay.

3.2 CHLORINATED PHENOLS AND PCBs

Quality assurance for analysis of chlorophenols and PCBs involved checking for contamination following extraction, using spiked samples to determine percent recoveries, and performing duplicate analyses. For the check on contamination in the extraction procedure, nine tissue samples and ten sediment samples were used, while for checking for the percent recovery, nine tissue samples and ten sediment samples were used. Contamination was found in only one tissue sample for pentachlorophenol (0.0003 µg/g), while all other extraction samples for both tissues and sediments were below detection and thus uncontaminated. Detection limits were as follows:

	SEDIMENTS	TISSUE
trichlorophenol	0.005 µg/g	0.0002 µg/g
tetrachlorophenol	0.005 µg/g	0.0002 µg/g
pentachlorophenol	0.005 µg/g	0.0002 µg/g
PCBs	0.010 µg/g	0.001 µg/g

The following are the percent recoveries of spiked samples at concentrations of ten times the detection limit.

	Percent Recoveries (%)			
	SEDIMENTS		TISSUE	
	Range	Mean	Range	Mean
trichlorophenol	64.5-133	85.6	64.7-100	77.8
tetrachlorophenol	66.5-115	87.1	56.3-92.3	74.1
pentachlorophenol	59.1-112	83.7	68 - 87	76
PCBs	64 - 93	83.3	65.3-105	83.4

The spiked samples consisted of the organic in question being put into a solvent, and indicate possible losses in the analytical process past the point of extraction. Due to the artificial nature of this quality control process, losses which exist for the spike do not necessarily occur in the analysis of the actual sample. No corrections have been applied to the data, and these recovery data will only be taken into account when examining whether Water Quality Objectives are achieved.

B.C. Ministry of Environment Water Quality Objectives for Boundary Bay are that the maximum PCB concentration in sediments should be 0.03 µg/g (dry-weight). This Objective was achieved for all samples from the Bay.

Eleven duplicate sediment and eight tissue analyses were performed. For the sediments, all duplicates except one were below the detection limits of 0.005 µg/g for each of the chlorophenols and 0.010 µg/g for PCBs. The one exception was a duplicate pentachlorophenol analysis, each of the duplicates being at the detection limit. Duplicate analyses for muscle were as follows:

	ng/g wet-weight							
	Duplicate1		Duplicate 2		Duplicate 3		Duplicate 4	
	#1	#2	#1	#2	#1	#2	#1	#2
Trichlorophenol	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2
Tetrachlorophenol	<0.2	0.6	0.4	0.8	<0.2	0.6	<0.2	<0.2
Pentachlorophenol	1.0	0.8	0.3	0.4	<0.2	<0.2	0.8	<0.2
PCBs	<1.0	<1.0	61.	37.	7.	8.	20.	21.

	ng/g wet-weight							
	Duplicate 5		Duplicate 6		Duplicate 7		Duplicate 8	
	#1	#2	#1	#2	#1	#2	#1	#2
Trichlorophenol	<0.2	<0.2	<0.2	< 0.2	<0.2	<0.2	<0.2	<0.2
Tetrachlorophenol	4.	3.	1.0	2.0	<0.2	<0.2	0.4	<0.2
Pentachlorophenol	2.	2.	0.8	2.0	0.6	0.4	2.	1.
PCBs	<1.	<1.	10.	4.0	31.	22.	34.	33.

These precision data indicate that large variations can exist for chlorophenols near the detection limit. In the case of PCBs, large variations are possible even when values are well removed from the detection limit.

3.2.1 CHLOROPHENOLS AND PCBs IN BENTHOS

Trichlorophenol was not detected (0.0002 µg/g) in soft-shelled clams sampled from either Site B-1 or B-5 (Table 10). It was also not detected in crabs (C. magister) from Site B-9, but was measured in 1 of 8 crab tissue samples from Site B-10 (Table 11). Trichlorophenol was not detected in the one composite hepatopancreas sample from crabs from Site B-9 or the four composite hepatopancreas samples from crabs from Site B-10.

Detectable concentrations of tetrachlorophenol and pentachlorophenol were found in some samples of both clams and crabs (C. magister). The maximum concentrations in soft-shelled clams were 0.003 µg/g (wet-weight) tetrachlorophenol and 0.002 µg/g pentachlorophenol, both from Site B-1. In crab tissue samples, the maximum concentrations were 0.010 µg/g tetrachlorophenol and 0.003 µg/g pentachlorophenol from Site B-10. In composite crab hepatopancreas samples, the maximum concentrations were 0.008 µg/g tetrachlorophenol from a composite from three males and four females, while the maximum pentachlorophenol concentration was 0.002 µg/g in a composite from three male crabs (C. magister) from Site B-10.

A Water Quality Objective for the Fraser River Estuary for maximum chlorophenol concentrations in fish muscle is 0.100 µg/g as the sum of tri-, tetra-, and pentachlorophenol (Swain and Holms 1985). Although not directly applicable to Boundary Bay benthos, concentrations measured in both soft-shelled clams and crab muscle and hepatopancreas samples were well below this Objective. Therefore, there is little concern for chlorophenol concentrations in these benthos from Boundary Bay.

The maximum concentrations of PCBs were 0.015 µg/g in soft-shelled clams from Site B-1 (Table 10) and 0.031 µg/g in crab tissue from Site B-10. The maximum PCB concentration in crab hepatopancreas was 0.035 µg/g in a composite from four male crabs (C. magister). A Water Quality Objective for the Fraser River Estuary for maximum PCB concentrations in fish muscle is 0.500 µg/g (Swain and Holms 1985). Although not directly applicable to Boundary Bay benthos, concentrations measured in both soft-shelled clams and crabs were well below this Objective. Therefore, there is

little concern for PCB concentrations in these benthos from Boundary Bay.

3.2.2 CHLOROPHENOLS AND PCBs IN FISH

Trichlorophenol was measured in only one fish sample; Pacific sandab from Site B-10 (Table 12) at a concentration of 0.009 µg/g. All other 33 samples had trichlorophenol concentrations below detection (<0.0002 µg/g).

Interestingly, the highest concentrations of both tetrachlorophenol and pentachlorophenol were measured in Pacific sandab from Site B-10, at concentrations of 0.010 µg/g and 0.007 µg/g, respectively.

A Water Quality Objective for the Fraser River Estuary for maximum chlorophenol concentrations in fish muscle is 0.100 µg/g as the sum of tri-, tetra-, and pentachlorophenol (Swain and Holms 1985). Although not directly applicable to Boundary Bay, concentrations measured in all the fish species collected were well below this Objective. Therefore, there is little concern for chlorophenol concentrations in fish from Boundary Bay.

The maximum PCB concentrations were in shiner perch from Site B-9, at 0.061 µg/g (Table 12). A Water Quality Objective for the tributaries to Boundary Bay for maximum PCB concentrations in small whole fish subject to predation is 0.100 µg/g (Swain and Holms 1988). Although not directly applicable to Boundary Bay proper, concentrations measured in fish from Boundary Bay were below this Objective. Therefore, there is little concern for PCB concentrations in fish from Boundary Bay, although PCBs in starry flounder livers seem to be magnified over concentrations in the muscle.

3.2.3 CHLOROPHENOLS AND PCBs IN SEDIMENTS

All sediment samples from all ten sites had non-detectable (<0.005 µg/g dry-weight) concentrations of tri-, tetra-, and pentachlorophenol (Table 13).

PCB concentrations were below detection (<0.010 µg/g) at all sites except Site B-10, where the maximum concentration was 0.017 µg/g (Table 13). This was the site with the smallest sediment particle size. A Water Quality Objective for Boundary Bay for maximum PCB concentrations in sediments is 0.030 µg/g (Swain and Holms 1988). Concentrations measured in Boundary Bay sediments were below this Objective. Therefore, there is little concern for PCB concentrations in sediments from Boundary Bay.

For sediments collected from above the five pump stations (Table 14), chlorophenols could not be detected (<0.005 µg/g) except for pentachlorophenol at Site P-5, where pentachlorophenol was measured at the detection limit. This reveals that the drainage ditches likely are not sources of chlorophenols. PCBs were usually below detection (<0.010 µg/g) except at Site P-2 (0.034 µg/g) and Site P-4 (0.011 µg/g). Swain and Alexander (1981) previously have reported on high concentrations of PCBs near Sites B-3 and B-4.

Sediments collected from near the mouths of the three tributaries (Table 15) had non-detectable chlorophenol and PCB concentrations, except at Site R-2 where 0.024 µg/g PCB was measured in the sediments. This indicates that some PCBs may be entering Boundary Bay from the Nicomekl River. There are no known sources of PCBs to the Nicomekl River system.

3.2.4 CONCLUSIONS

Laboratory quality assurance data indicated that contamination was present in only one tissue sample for pentachlorophenol (0.0003 µg/g), while all other extraction samples for both tissues and sediments were below detection and thus uncontaminated. The reproducibility of some of the results for flesh was sometimes erratic.

Chlorophenol and PCB concentrations in benthos, fish, and sediments were always below the Water Quality Objective concentrations directly applicable to Boundary Bay, or those for the Fraser River Estuary. PCBs in starry flounder livers seem to be magnified over concentrations in the muscle.

3.3 PHTHALATE ESTERS

Phthalic acid esters represent a large family of organic chemicals used widely as plasticizers (Leah 1977). Six phthalate esters were measured in this survey. These were dimethyl, diethyl, di-n-butyl, butyl benzyl, di-n-octyl, and bis (2-ethylhexyl). Quality assurance for analysis of phthalate esters involved checking for contamination following extraction using nine tissue samples and ten sediment samples, and checking the percent recovery of nine tissue samples and ten sediment samples. Contamination was found in both the tissues and sediments of the extraction blanks.

Contamination was present for each of the phthalate esters in at least one extraction blank, except for dimethyl phthalate and butyl benzyl phthalate in sediments, and dimethyl phthalate, diethyl phthalate, and di-n-octyl phthalate in tissues. The following levels were detected in the extraction blanks:

Phthalate Ester	No. of Sediment Samples with Detectable Values	Measured Values (µg/g dry weight)	No. of Tissue Samples with Detectable Values	Measured Values (µg/g wet weight)
Diethyl	1	0.11	0	-
Di-n-butyl	4	0.15,0.19, 0.16,0.15	2	0.15,0.04
Butyl Benzyl	0	-	2	0.06,0.071
Di-n-octyl	1	0.17	0	-
Bis (2-ethyl-hexyl)	3	0.15,0.18 0.26	7	0.03,0.07, 0.06,0.09, 0.03,0.06, 0.06

Only when phthalate esters are present in sediments and muscle at concentrations greater than the above maximum concentrations for each phthalate ester will we consider that phthalates are present in the sediments or muscle, and not simply an artifact of the laboratory analyses.

Percent recoveries for spiked samples at concentrations ten times the detection limit were as follows:

Phthalate Ester	Sediments Range	Mean	Std. Dev.	Muscle Range	Mean	Std. Dev.
Dimethyl	56.8-98.5	79.2	12.3	63.7-109	81.5	13.1
Diethyl	50-115	77.4	18.6	53.7-93.4	74.2	11.7
Butyl Benzyl	81-116	97.6	11.4	56.6-115	85.5	18.6
Di-n-octyl	56.6-127	82.5	21.4	59.5-108	79.9	15.9

The spiked samples consisted of the organic in question being put into a solvent, and indicate possible losses in the analytical process past the point of extraction. Due to the artificial nature of this quality control process, losses which exist for the spike do not necessarily occur in the analysis of the actual sample. No corrections have been applied to the data.

Duplicate analyses were also performed for 11 sediment samples for the six phthalate esters. Normally, the six phthalates were below the detection limit of 0.10 µg/g dry-weight. However, the following differences were measured:

Phthalate Ester	Duplicate #1		Duplicate #2		Duplicate #3		Duplicate #4		Duplicate #5	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Diethyl	<0.1	0.29	0.47	0.21	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Di-n-butyl	0.16	0.29	<0.1	0.24	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bis (2-ethylhexyl)	0.81	0.97	0.18	0.51	<0.1	0.63	0.11	0.10	0.55	0.43
					Duplicate #6				0.51	0.58

These data point out that the precision of the diethyl, di-n-butyl, and bis (2-ethylhexyl) phthalate analyses is poor, likely due to the contamination problems noted for the extraction blanks.

Duplicate analyses were also performed on eight tissue samples for the six phthalate esters. Dimethyl phthalate ester measurements were always below the detection limit of 0.01 µg/g wet-weight. Differences in diethyl and di-n-octyl phthalates occurred only once, with duplicate values of 0.03 and <0.01 µg/g, and 0.16 and <0.01 µg/g, respectively. The following differences were measured for the other three phthalate esters:

Phthalate Ester	Duplicate #1		Duplicate #2		Duplicate #3		Duplicate #4	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Di-n-butyl	0.27	0.13	0.081	0.11	0.03	<0.01	<0.01	0.078
Butyl Benzyl	<0.01	<0.01	0.052	0.045	<0.01	<0.01	0.05	0.060
Bis (2-ethyl-hexyl)	0.16	0.10	0.18	0.17	0.064	0.056	0.11	0.14

Phthalate Ester	Duplicate #5		Duplicate #6		Duplicate #7		Duplicate #8	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Di-n-butyl	0.01	<0.01	0.05	0.07	<0.01	0.051	0.096	0.13
Butyl Benzyl	<0.01	0.10	0.10	0.08	<0.01	0.087	0.050	<0.01
Bis (2-eth-ylhexyl)	<0.01	<0.01	0.26	0.20	0.12	0.15	0.3	0.41

3.3.1 PHTHALATE ESTERS IN BENTHOS

Data for phthalate esters in soft-shelled clams are summarized in Table 16 while those for crabs (C. magister) are in Table 17. Although contamination of muscle samples (no clams or crabs) was apparent for phthalate esters, maximum values measured exceeded the contamination levels by factors from two to three times.

For all the phthalate esters measured, except di-n-butyl and bis (2-ethylhexyl), the median value was less than the detection limit for clams at Sites B-1 and B-5 and for crabs (C. magister) at Sites B-9 and B-10. The maximum values for these two phthalates for clams were 0.28 µg/g for clams at Site B-1 and 0.42 µg/g for crab muscle at Site B-9, and 0.30 µg/g for clams at Site B-5 and 0.82 µg/g for crab hepatopancreas at Site B-10, respectively.

3.3.2 PHTHALATE ESTERS IN FISH

Dimethyl, diethyl, and di-n-octyl phthalate esters were not usually detected (<0.01 µg/g) in the fish species sampled, although di-n-octyl phthalate was measurable at high concentrations in

livers from starry flounders (Site B-10). This implies magnification in the livers relative to the muscle.

For di-n-butyl phthalate for which contamination was measured to as high as 0.15 µg/g, maximum values higher than this contamination level were measured only in livers of starry flounders from Site B-10, with a maximum concentration of 0.31 µg/g (Table 18). This implies magnification in the livers relative to the muscle. The mean concentration for the starry flounder livers was 0.20 µg/g, above the contamination level, which implies that the detectable values are possibly due to contamination, since the concentrations in the remaining sample was low enough to offset the two high values. The duplicate analyses for di-n-butyl phthalate above confirm that precision can be very poor for this phthalate.

A similar situation exists for butyl benzyl phthalate in terms of analytical precision and mean concentrations relative to the contamination present in the analyses (0.071 µg/g). When these factors are considered, only the data for buttersole and livers from starry flounders from Site B-10 appear to warrant further consideration. (Three of four results for staghorn sculpin from Site B-9 were <0.01 µg/g; therefore, the one value of 0.52 µg/g has not been considered in our discussion.) The maximum concentrations were 1.47 µg/g in buttersole and 0.83 µg/g in starry flounder livers (Table 18). The fact that this phthalate ester was present at such high concentrations at the offshore site leads one to suspect that butyl benzyl phthalate may be present and not simply an artifact of the ubiquitous nature of phthalates, and that it is magnified in starry flounder livers.

The level of contamination identified for the bis(2-ethylhexyl) phthalate analysis was 0.09 µg/g. All mean concentrations except for Pacific sandab and all maximum concentrations were above the contamination level for all species (Table 18). Mean concentrations were about 0.2 to 0.3 µg/g, except for Pacific sandab from Site B-10 which was 0.007 µg/g and buttersole from the same site with a mean concentration of 0.46 µg/g. Muscle from starry flounders (Site B-10) had a mean concentration of 0.12 µg/g, while the mean concentrations for the livers was 0.46 µg/g, which implies magnification in the livers relative to the muscle.

The data for the precision for the bis(2-ethylhexyl) phthalate analysis above indicate that precision was good. Due to this, the

high levels of this phthalate relative to measured contamination levels, and the wide-spread presence of high bis(2-ethylhexyl) phthalate values, it is likely that bis(2-ethylhexyl) phthalate is accumulating in fish from Boundary Bay.

In the 1988 survey of Fraser River fish, phthalate esters were not usually measured in starry flounders at concentrations above the level of contamination cited above (Swain and Walton 1989).

3.3.3 PHTHALATE ESTERS IN SEDIMENTS

Data for phthalate esters in Boundary Bay sediments are summarized in Table 19. Dimethyl phthalate was not detected in any of the sediments from the ten sites in Boundary Bay. Diethyl phthalate was detected in only one sample from Site B-6, at 0.15 µg/g. This value is so close to the level of contamination measured (0.11 µg/g) that it is likely just an artifact of contamination.

For di-n-butyl phthalate, all mean and median values were below detection (0.10 µg/g), and the maximum concentration of 0.26 µg/g at Site B-6 was approximately the same as the level of contamination of 0.19 µg/g. When this is taken into account with the precision data for di-n-octyl phthalate, it is likely that this value is an artifact of the contamination associated with this analysis.

Butyl benzyl phthalate was detected in only one sample from Site B-9, at 0.16 µg/g. This value is so close to the detection limit that it is likely just an artifact of sampling. Data for di-n-octyl phthalate from only one site (B-7) were above the contamination level of 0.17 µg/g. At this site, the maximum value was 0.31 µg/g. It is likely that there may be some slight contamination occurring, based on the value being about twice the contamination level and the fact that the precision was good.

The minimum and mean concentrations for four of the ten sites, and the maximum concentrations for six of the ten sites for bis(2-ethylhexyl) phthalate were above the contamination level of 0.26 µg/g. The precision of this test, however, is poor. Based upon the number of measurable concentrations and fact that this phthalate was also frequently measured in fish and other benthos, it

is likely that bis(2-ethylhexyl) phthalate is present and not an artifact of contamination.

Data for sediments collected in the ditches above the pump stations (Table 20) and at the mouths of the three tributaries (Table 21) were generally below the detection limit (0.10 µg/g) or the level of contamination associated with the test and cited above. The exception to this was for bis(2-ethylhexyl) phthalate which was measured in the ditches at 1.34 µg/g at Site P-2 and 0.68 µg/g at Site P-4. In the three tributaries, the measured values of this ester were 0.49 µg/g in the Serpentine River, 0.33 µg/g in the Nicomekl River, and 0.56 µg/g in the Little Campbell River.

3.3.4 CONCLUSIONS

Contamination was present for phthalates for most of the environmental compartments. Precision of the analytical procedure was also often poor, but this may have been a result of contamination commonly associated with these characteristics.

Bis(2-ethylhexyl) phthalate was measurable at values higher than the contamination present in clams, crabs, fish, and sediments. The concentrations of this phthalate ester were usually sufficiently elevated relative to the blanks that we can conclude that there is some contamination of this phthalate occurring.

Di-n-butyl phthalate, butyl benzyl phthalate, di-n-octyl phthalate, and bis(2-ethylhexyl) phthalate were all at considerably higher concentrations in livers than in the muscle of starry flounders, implying that magnification of these phthalates is taking place in this species.

3.4 POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

PAHs are commercially-used compounds, are naturally present in coal and petroleum, and are also formed during the incomplete combustion of hydrocarbons (Garrett 1982). PAHs measured in this survey included acenaphthene, acenaphthylene, anthracene, benzo (a) anthracene, benzo (a) pyrene, benzo (b) fluoranthene, benzo (g,h,i) perylene, benzo (k) fluoranthene, chrysene, dibenzo (a,h) anthracene,

fluoranthene, fluorene, indeno (1,2,3-c,d) pyrene, naphthalene, phenanthrene, and pyrene.

Quality assurance of PAHs involved checking for contamination following extraction using nine tissue samples and ten sediment samples, and checking the percent recovery of nine tissue samples and ten sediment samples. Contamination was found in only one extraction blank for sediments; for acenaphthylene at 0.013 µg/g. For both the tissues and sediments, it was not detected in any of the other extraction blanks.

The spiked samples consist of the organic in question being put into a solvent, and results indicate possible losses in the analytical process past the point of extraction. Due to the artificial nature of this quality control process, losses which exist for the spike do not necessarily occur in the analysis of the actual sample. No corrections have been applied to the data. Percent recoveries for spiked samples at concentrations ten times the detection limit were as follows:

	Sediments			Muscle		
PAHs	Range	Mean	Std. Dev.	Range	Mean	Std. Dev.
Acenaphthene	61.4-112	85.9	16.3	46.5-86.6	65.1	14.0
Benzo(a)pyrene	48.4-115	82.8	20.2	64.5-83.5	73.0	5.9
Chrysene	55.9-110	82.6	16.8	62.7-92.0	72.4	9.1
Dibenzo(a,h) anthracene	61.5-110	86.4	16.9	51.0-78.7	62.0	7.9
Fluorene	54.0-106	81.5	16.3	42.1-114	71.2	20.5
Phenanthrene	66.9-115	91.7	16.1	54.1-102	74.1	14.4
	Mean	85.1		Mean	69.6	

These recoveries for muscle are the same or lower than has been reported by the same laboratory for the same analyses (Swain and Walton 1989).

Eight duplicate analyses of PAHs in muscle were identical, with the concentrations for all the PAHs being below varying detection limits, depending on the PAH. Detection limits were as follows: acenaphthene, acenaphthylene, fluorene, naphthalene,

phenanthrene, and anthracene, 0.004 µg/g; benzo (a) anthracene, fluoranthene, chrysene, and pyrene, 0.01 µg/g; and benzo (a) pyrene, benzo (b) fluoranthene, benzo (g,h,i) perylene, indeno (1,2,3-c,d) pyrene, dibenzo (a,h) anthracene, and benzo (k) fluoranthene, 0.02 µg/g.

Such was not the case for PAHs in sediments, where considerable differences existed for some PAHs in some samples. The following results are only for those duplicate analyses which were detectable. Many of the eleven duplicates were less than the detection limit. The values listed under the title "Duplicate" for individual PAHs therefore are not necessarily all for the same sample.

PAH	DUPLICATE	DUPLICATE	DUPLICATE	DUPLICATE
ACENAPHTHENE	<0.005 0.013	0.10 0.13		
ACENAPHTHYLENE	0.042 0.078	<0.005 0.015	0.033 0.035	0.053 0.058
ANTHRACENE	0.02 <0.005	0.031 0.030	0.026 0.018	0.096 0.10
BENZO(A) ANTHRACENE	0.054 <0.01	0.044 <0.01	0.022 <0.01	0.082 0.11
BENZO(A) PYRENE	<0.02 0.026			
BENZO(B) FLUORANTHENE	<0.02 0.049	0.16 0.45	0.027 0.023	<0.02 0.026
BENZO(G,H,I) PERYLENE	<0.02 0.043	0.046 0.049	0.028 0.048	
BENZO(K) FLUORANTHENE	<0.02 0.038	0.070 0.020		
CHRYSENE	0.054 0.081	0.019 <0.01	<0.01 0.017	
DIBENZO (A,H) ANTHRACENE	0.80 0.76			
FLUORANTHENE	0.036 0.018	0.071 0.012	0.52 0.37	0.021 0.033
FLUORENE	0.014 0.020	0.062 0.054	0.039 0.033	
INDENO (1,2,3-C,D) PYRENE	0.026 0.032	0.17 0.10		
NAPHTHALENE	0.015 0.012	0.008 <0.005	<0.005 0.011	0.055 0.037
PHENANTHRENE	0.02 <0.005	0.026 0.015	0.082 0.10	0.020 0.025
PYRENE	0.031 0.012	0.014 <0.01	0.021 0.016	<0.010 0.015

PAH	DUPLICATE	DUPLICATE	DUPLICATE
BENZO(B) FLUORANTHENE	0.055 0.065	0.033 0.029	0.069 0.024
FLUORANTHENE	0.46 0.53	0.036 0.018	0.085 0.035
FLUORENE	0.016 <0.005	0.055 0.032	0.005 0.005
PHENANTHRENE	0.26 0.24		
PYRENE	0.46 0.41		

3.4.1 PAHs IN BENTHOS AND FISH

PAHs could not be detected in any of the soft-shelled clams, crabs, or fish tested. Detection limits were as follows:

acenaphthene, acenaphthylene, fluorene, naphthalene, phenanthrene, and anthracene, 0.004 µg/g; benzo (a) anthracene, fluoranthene, chrysene, and pyrene, 0.01 µg/g; and benzo (a) pyrene, benzo (b) fluoranthene, benzo (g,h,i) perylene, indeno (1,2,3-c,d) pyrene, dibenzo (a,h) anthracene, and benzo (k) fluoranthene, 0.02 µg/g. The data are summarized in Tables 22, 23, and 24.

3.4.2 PAHs IN SEDIMENTS

Data for PAHs in sediments are summarized in Table 25. Acenaphthene was detected at five of the ten stations sampled, to as high as 0.081 µg/g at Site B-10. Mean and median concentrations at all stations were below the detection limit of 0.005 µg/g, with all but two of the fifty values for Boundary Bay sediments being below the Water Quality Objective for Burrard Inlet of 0.05 µg/g (Nijman and Swain 1990). This Objective is one-tenth the lowest AET for Puget Sound. Acenaphthene was not detectable at the mouths of the tributaries (<0.005 µg/g - Table 27), but could be measured in the ditch sediments leading to three of the five pump stations (Table 26). Concentrations were 0.13 µg/g at Site P-2, 0.058 µg/g at Site P-4, and 0.10 µg/g at Site P-5. Thus the pumping stations are minor sources of acenaphthene to Boundary Bay, although the tributaries do not appear to be. There does not appear to be a relationship between concentrations measured at these sources and those in Boundary Bay adjacent to these sources (Sites B-2, B-4, and B-5).

Measurable concentrations of acenaphthylene were found at four of the ten monitoring stations (Table 25). Mean and median concentrations at all stations except Site B-2 were below the detection limit of 0.005 µg/g, with all of the fifty values for Boundary Bay sediments being at or below the sediment quality criterion for Burrard Inlet of 0.06 µg/g (Nijman and Swain 1990). This Objective is one-tenth the lowest AET for Puget Sound. Acenaphthylene was not detectable at the mouths of the tributaries (<0.005 µg/g - Table 27), but could be measured in the ditch sediments leading to two of the five pump stations (Table 26). Concentrations were 0.046 µg/g at Site P-2 and 0.033 µg/g at Site P-5. Thus the pumping stations are very minor sources of acenaphthylene to Boundary Bay, although the tributaries do not appear to be. There does not appear to be a relationship between

concentrations measured at this source and those in Boundary Bay adjacent to the source.

Anthracene was detected more frequently than these other two PAHs, with measurable mean concentrations at three of the ten sites, and measurable maximum concentrations at seven of the ten sites (Table 25). All values were less than the Sediment Quality Objective for Burrard Inlet of 0.1 µg/g, which is one-tenth the lowest AET for Puget Sound (Nijman and Swain 1990). Anthracene was detected (Table 27) at the mouth of the Nicomekl River at 0.029 µg/g (Site R-2), and in the ditches leading to three of the five pump stations (Table 26). Concentrations at these three sites were 0.057 µg/g at Site P-2, 0.020 µg/g at Site P-3, and 0.096 µg/g at Site P-5. Thus the pump stations and the Nicomekl River are sources of anthracene to Boundary Bay, although there does not appear to be a relationship between concentrations measured at these sources and those in Boundary Bay adjacent to these sources.

The Sediment Quality Objective for benzo(a) anthracene in Burrard Inlet is a maximum of 0.13 µg/g (Nijman and Swain 1990). The maximum concentration measured was 0.072 µg/g, at Site B-1 (Table 25). This is about one-half the Objective, which in turn is one-tenth the lowest AET value for Puget Sound sediments. Benzo (a) anthracene was measured in the sediments at the mouth of the Little Campbell River (0.25 µg/g - Table 27) and in the ditch leading to one of the pump stations (0.19 µg/g at Site P-4 - Table 26). This indicates that the Little Campbell River is a considerable contributor of benzo (a) anthracene to Boundary Bay, while the pump stations can also be contributors.

Benzo (a) pyrene could not be detected in Boundary Bay sediments (<0.02 µg/g - Table 25) or the ditches leading to the pump stations (Table 26). Measurable quantities were found near the mouth of the Serpentine (0.11 µg/g) and the Nicomekl (0.068) rivers (Table 27). Thus, these two tributaries are net contributors of benzo (a) pyrene to Boundary Bay.

Benzo (b) fluoranthene was detected in all five samples from Site B-2, and four of the five samples from Site B-10 (Table 25). All concentrations were less than the Sediment Quality Objective for Burrard Inlet of 0.32 µg/g for all benzo fluoranthenes (Nijman and Swain 1990). Benzo (b) fluoranthene was not detected (<0.02 µg/g) in any of the samples from the ditches leading to the pump

stations (Table 26) or in sediments from the mouths of the tributaries (Table 27). The sources of the measurable concentrations in Boundary Bay sediments is not known.

Detectable concentrations of benzo (g,h,i) perylene were found at all but two of the ten sites in Boundary Bay (Table 25), although most values at all ten sites were below detection (<0.02 µg/g). The maximum concentrations from three of the ten sites were approaching the lowest AET for Puget Sound of 0.7 µg/g, which was the basis for the Sediment Quality Objective for Burrard Inlet of 0.07 µg/g (Nijman and Swain 1990). Benzo (g,h,i) perylene could not be detected in sediments from ditches leading to the pump stations (Table 26) or in the tributaries to Boundary Bay (Table 27).

Benzo (k) fluoranthene was detected at only three sites, with it being detected most frequently and at the highest concentrations at the offshore Site B-10 (Table 25). The maximum concentration of 0.13 µg/g is less than one-half the Sediment Quality Objective of 0.32 µg/g for all benzo fluoranthenes in Burrard Inlet, which itself is one-tenth the lowest AET for Puget Sound (Nijman and Swain 1990). Benzo (k) fluoranthene could not be detected (<0.02 µg/g) in the ditches leading to the pump stations (Table 26) or in the sediments at the mouths of the three tributaries (Table 27).

The Sediment Quality Objective for chrysene in Burrard Inlet is a maximum concentration of 0.14 µg/g, again one-tenth of the lowest AET for Puget Sound (Nijman and Swain 1990). The maximum concentration measured in Boundary Bay sediments was only about one-half of the Objective concentration, 0.074 µg/g at Site B-6 near the Serpentine River (Table 25). Almost all values at all the sites were below detection (0.01 µg/g). Chrysene was detected at only one of the five ditches leading to the pumping stations (Table 26) (P-2) at a concentration of 0.38 µg/g and only in the sediments at the mouth of the Nicomekl River (Site R-2) at a concentration of 0.2 µg/g (Table 27). Thus some of the ditches and the tributaries are contributors of chrysene to Boundary Bay sediments.

Dibenzo (a,h) anthracene was found at detectable concentrations in all five samples from Site B-6, opposite the Serpentine River, to as high as 1.24 µg/g (Table 25). All these values exceeded the Sediment Quality Objective of 0.06 µg/g for Burrard Inlet, which is about one-third the lowest AET for Puget Sound (Nijman and Swain 1990). The maximum concentration at the

other two sites opposite the tributaries (Sites B-7 and B-8) were also above the Objective, as was the maximum concentration at the off-shore site. Ironically, dibenzo (a,h) anthracene was not detected (<0.02 µg/g) at any of the ditch sites leading to the pump stations (Table 26) or in sediments from the mouths of the three tributaries (Table 27).

Fluoranthene was detected in more samples from more sites in Boundary Bay than any other PAH measured during this survey (Table 25). The maximum concentrations in Boundary Bay sediments were 0.91 µg/g at Site B-2, opposite the pump station at Site P-2; 0.78 µg/g at Site B-6, opposite the Nicomekl River at Site R-2; and 0.4 µg/g at the offshore site (B-10). Several values exceeded the Objective for Burrard Inlet, although not the AET. The Sediment Quality Objective for Burrard Inlet is a maximum concentration of 0.17 µg/g, which is one-tenth the lowest AET for Puget Sound sediments (Nijman and Swain 1990). Fluoranthene could not be detected (<0.01 µg/g) in any of the sediments collected at the mouths of the tributaries (Table 27), but was found in four of five ditches leading to the pump stations (Table 26). The maximum concentration found in the samples from the ditches was at Site P-2, at a concentration of 0.49 µg/g. As discussed earlier, sediments from Boundary Bay opposite this site had the highest concentrations of fluoranthene from any other site in Boundary Bay. Thus, the pump stations are net contributors of fluoranthene to the Bay.

Fluorene was also detected (0.005 µg/g) frequently in Boundary Bay sediments (Table 25), with maximum concentrations occurring at Site B-3 (0.079 µg/g) opposite the pump station at Site P-3; at Site B-6 (0.075 µg/g) opposite the mouth of the Nicomekl River at Site R-2; and at the offshore site B-10 (0.039 µg/g). The Sediment Quality Objective for Burrard Inlet is 0.05 µg/g, one-tenth of the lowest AET for Puget Sound sediments (Nijman and Swain 1990). Thus, some of the maximum concentrations exceed the Burrard Inlet Objective but not the AET. Fluorene was detected in all five ditches leading to the pump stations (Table 26), with the maximum concentration of 0.085 µg/g occurring at Site P-4. Fluorene was also detected in sediments collected in the mouths of two of the three tributaries (Table 27); 0.025 µg/g at Site R-1 in the Serpentine River and at Site R-3 in the mouth of the Little Campbell River (0.034 µg/g). Thus the pump stations and the tributaries are net contributors of fluorene to the Boundary Bay sediments.

Although indeno (1,2,3-c,d) pyrene was detected in four of the five samples from the offshore site (B-10), the maximum concentration of 0.4 µg/g was measured at Site B-3, opposite the pump station at Site P-3 (Table 25). The Sediment Quality Objective for Burrard Inlet for indeno (1,2,3-c,d) pyrene is 0.06 µg/g, one-tenth the lowest AET for Puget Sound (Nijman and Swain 1990). Thus the maximum concentrations at both the sites are above the Burrard Inlet Objective, but below the lowest AET. Indeno (1,2,3-c,d) pyrene was measured in two of the five ditches leading to the pump stations (maximum 0.42 µg/g at Site P-2 : Table 26) and in all samples collected from the mouths of the three tributaries (maximum 0.096 µg/g in the Serpentine River at Site R-1 : Table 27). Thus, the pump stations and the tributaries are net contributors of indeno (1,2,3-c,d) pyrene to Boundary Bay sediments.

Naphthalene was detected (0.005 µg/g) only at two adjacent sites in Boundary Bay, and in four of the five samples from both sites. The maximum naphthalene concentration of 0.021 µg/g was measured at Site B-1 (Table 25), well below the Sediment Quality Objective of 0.20 µg/g for Burrard Inlet (Nijman and Swain 1990). Naphthalene was measured at four of the five ditches (maximum naphthalene concentration of 0.16 µg/g at Site P-2) leading to the pump stations (Table 26) and at the mouths of two of the three tributaries (maximum naphthalene concentration of 0.073 µg/g in the mouth of the Serpentine River at Site R-1 - Table 27). Thus the tributaries and the pump stations are net contributors of naphthalene to Boundary Bay.

Phenanthrene was detected (0.005 µg/g) most frequently at Sites B-4, B-5, and B-6, and in four of five samples at each site. The maximum phenanthrene concentration was 0.092 µg/g (Table 25) was at Site B-5, which is below the Sediment Quality Objective of 0.15 µg/g (one-tenth the lowest Puget Sound AET) for Burrard Inlet (Nijman and Swain 1990). Phenanthrene was detected in three of the five ditches leading to the pump stations (maximum phenanthrene concentration of 0.5 µg/g at Site P-2 - Table 26) but in no sediment samples collected from the mouths of the three tributaries (Table 27). Thus the pump stations are net contributors of phenanthrene to Boundary Bay.

Pyrene was usually not detected (<0.01 µg/g) in Boundary Bay sediments except at the offshore site where the maximum

concentration was 0.3 µg/g (Table 25). This is approximately the same as the Sediment Quality Objective of 0.26 µg/g for Burrard Inlet (Nijman and Swain 1990). Pyrene was measured in four of the five ditches leading to the pump stations (maximum pyrene concentration of 1.16 µg/g at Site P-2 - Table 26) but in no sediment samples collected from the mouths of the three tributaries (Table 27). Thus the pump stations are not contributors of pyrene to Boundary Bay.

3.4.3 CONCLUSIONS

Both the pump stations and the tributaries are contributors of individual PAHs to Boundary Bay. The Sediment Quality Objectives for PAHs which apply to Burrard Inlet are not directly applicable to Boundary Bay, but are a good indicator of whether a concern should exist with respect to PAHs. Generally, the sediments of the Bay are below the Objective concentrations. For those relatively few sites where some of the measured values exceed the Objective concentration, concentrations measured in Boundary Bay sediments are below the lowest AET values for Puget Sound. This indicates that it is very unlikely that aquatic life in Boundary Bay are being impacted by these PAHs.

Further evidence in this regard is the fact that PAHs could not be detected in biota from Boundary Bay.

3.5 ORGANOCHLORINE PESTICIDES

Organochlorine pesticides measured in this survey were aldrin, alpha-chlordane, gamma-chlordane, dieldrin, DDT, DDE, DDD, endrin, endosulfan-I, endosulfan-II, endosulfan sulfate, heptachlor, heptachlor epoxide, lindane, methoxychlor, and toxaphene.

Quality assurance for organochlorine pesticides involved checking for contamination following extraction with nine blank samples in tissues and ten blank samples in sediments. As well, the percent recovery for spiked samples was checked with nine samples in tissues and ten samples in sediments. Organochlorine pesticides were not detected in any of the extraction blanks for either sediments or tissues. The spiked samples do not necessarily indicate losses that would occur in the analyses. The results in

Tables 28 to 33 have had no corrections made for the recovery data. Percent recoveries for the ten spiked sediment samples and the nine spiked tissue samples were as follows:

Organochlorine Pesticide	Tissue Range	Tissue Mean	Tissue Std. Dev.	Sediment Range	Sediment Mean	Sediment Std. Dev.
Aldrin	46.7- 22	82	22.5	52.1- 82.9	65.5	11.8
Alpha-Chlordane	55.3- 101	75	14.1	50.2- 109	67.9	21
Gamma-Chlordane	51.2- 102	72.9	13.7	51.1- 110	66.8	21.2
Dieldrin	52.9- 84	70.7	9.7	51.0- 97.9	70.5	16.1
DDT	68.6- 117	86.5	17.3	61.1- 101	77.3	13.1
DDD	55.1- 97.8	77.1	13.8	53.6- 81	68.9	9.4
DDE	76- 104	86.5	10.9	60.3- 91.4	72.9	10.0
Lindane	60.2-94.3	73.9	10.4	62.9- 85	70.6	7.1
Methoxychlor	57.6- 104	96.5	17.2	58.9- 104	82.7	15.4
		80.1			71.4	

3.5.1 ORGANOCHLORINE PESTICIDES IN BENTHOS

Organochlorine pesticides were not usually detected in the soft-shelled clams from either Sites B-1 or B-5 (Table 28). The most frequently detected pesticides with measurable concentrations at both sites were DDE with a value as high as 0.0004 µg/g, and endosulfan-I with a maximum value of 0.0003 µg/g.

This same trend was also noted for concentrations in crabs (C. magister), although the number of pesticides with measurable concentrations at both Sites B-9 and B-10 increased. Pesticides measured in crab muscle samples at both sites were alpha-chlordane, dieldrin, DDD, DDE, and endosulfan-I (Table 29). The most significant finding related to these data was that DDE was detectable in over one-half of the samples collected from each site. This is likely due to the fact that DDE is a breakdown product of DDT. The maximum DDE concentration was 0.005 µg/g (wet-weight) in muscle samples from Site B-9. In crab hepatopancreas samples, the maximum DDE concentration was 0.021 µg/g in crabs from Site B-10. DDE seemed to be magnified in the crab hepatopancreas.

3.5.2 ORGANOCHLORINE PESTICIDES IN FISH

Data for the organochlorine pesticides in fish are summarized in Table 30. DDE was measurable in almost every sample from each of the two sites. The maximum concentration of 0.012 µg/g was measured in livers of starry flounders from the offshore site, Site B-10. Alpha-chlordane was also measured in a considerable number of samples, although the highest concentration of 0.002 µg/g was found in shiner perch from Site B-9.

Certain pesticides could not be detected above varying detection limits at either of the sites in any of the samples. These pesticides included aldrin, endosulfan-II, endosulfan sulfate, heptachlor, heptachlor epoxide, methoxychlor, and toxaphene.

Magnification in livers from muscle of starry flounders was apparent only for DDE, where the lowest concentration in livers (0.0068 µg/g) was higher than the highest concentration in muscle (0.0051 µg/g).

3.5.3 ORGANOCHLORINE PESTICIDES IN SEDIMENTS

Data for the organochlorine pesticides in sediments are summarized in Table 31. Generally speaking, the organochlorine pesticides were not detectable in sediments from most of the sites sampled. Of note was the fact that some high concentrations were found in some of the samples collected from Sites B-3 and B-4. Maximum concentrations were 0.016 µg/g heptachlor at Site B-4 and 0.014 µg/g heptachlor epoxide at Site B-3. In the ditches leading to the pump stations (Table 32), most organochlorine pesticides were near or below varying detection limits. Two exceptions to this were for DDD and DDE, with maximum concentrations of 0.004 µg/g and 0.005 µg/g, respectively.

For sediments collected from near the mouths of the three tributaries, all values for the organochlorine pesticides were below varying detection limits, except for endosulfan-II which was detected at the mouth of the Nicomekl River (Table 33) at a concentration of 0.0015 µg/g.

3.5.4 CONCLUSIONS

Organochlorine pesticides were not detected in any of the extraction blanks for tissues or for sediments.

Organochlorine pesticides were not usually detected in the crabs or soft-shelled clams, although DDE was measured in the soft-shelled clams and in over one-half of the crab samples and in almost every fish sample from each of the two sites. Magnification in livers from muscle of starry flounders was apparent only for DDE.

Generally speaking, the organochlorine pesticides were not detectable in sediments from most of the sites sampled in Boundary Bay. In the ditches leading to the pump stations and near the mouths of the three tributaries, most organochlorine pesticides were near or below varying detection limits.

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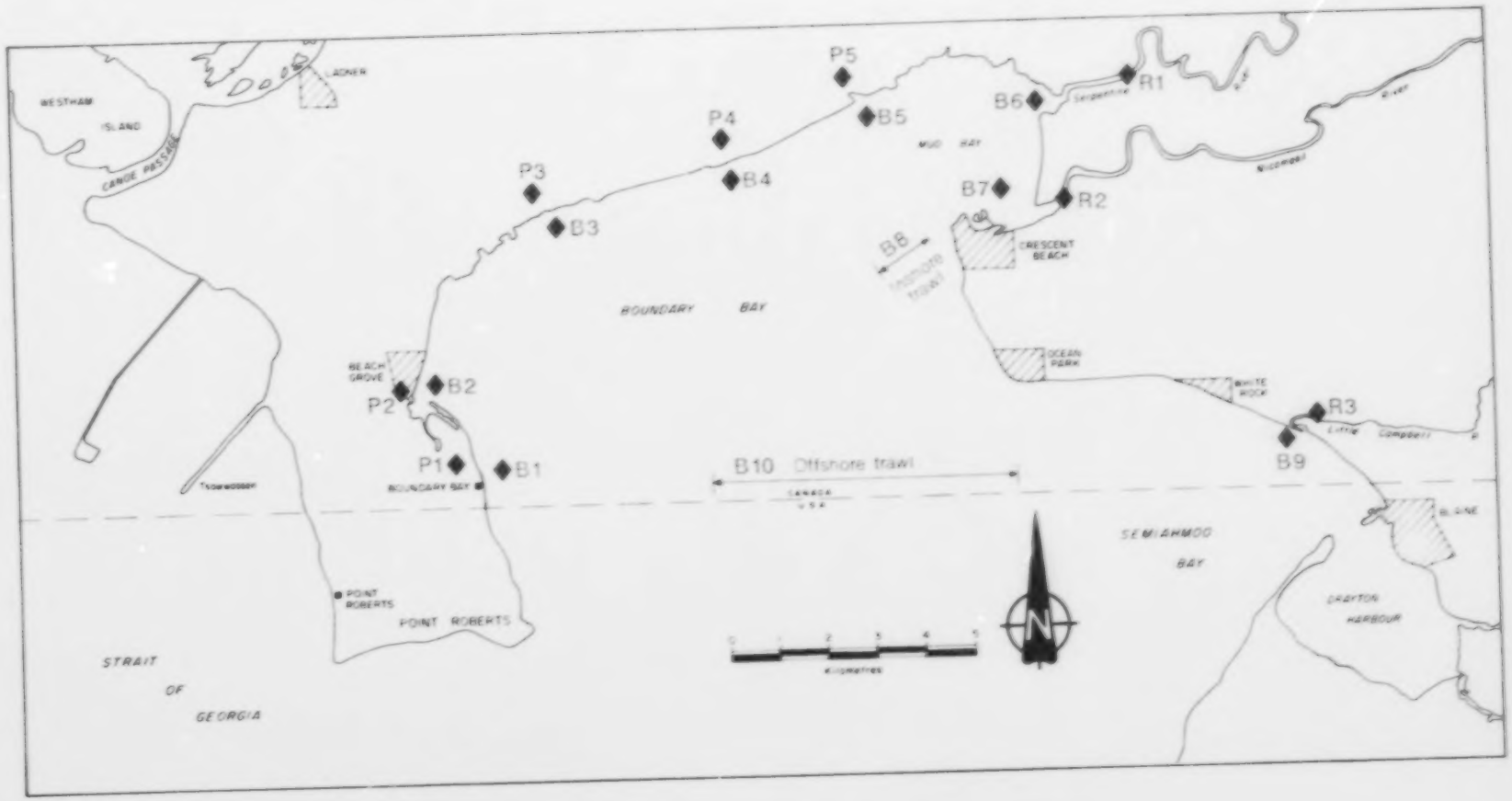

FIGURE 1 SAMPLING SITES-1989

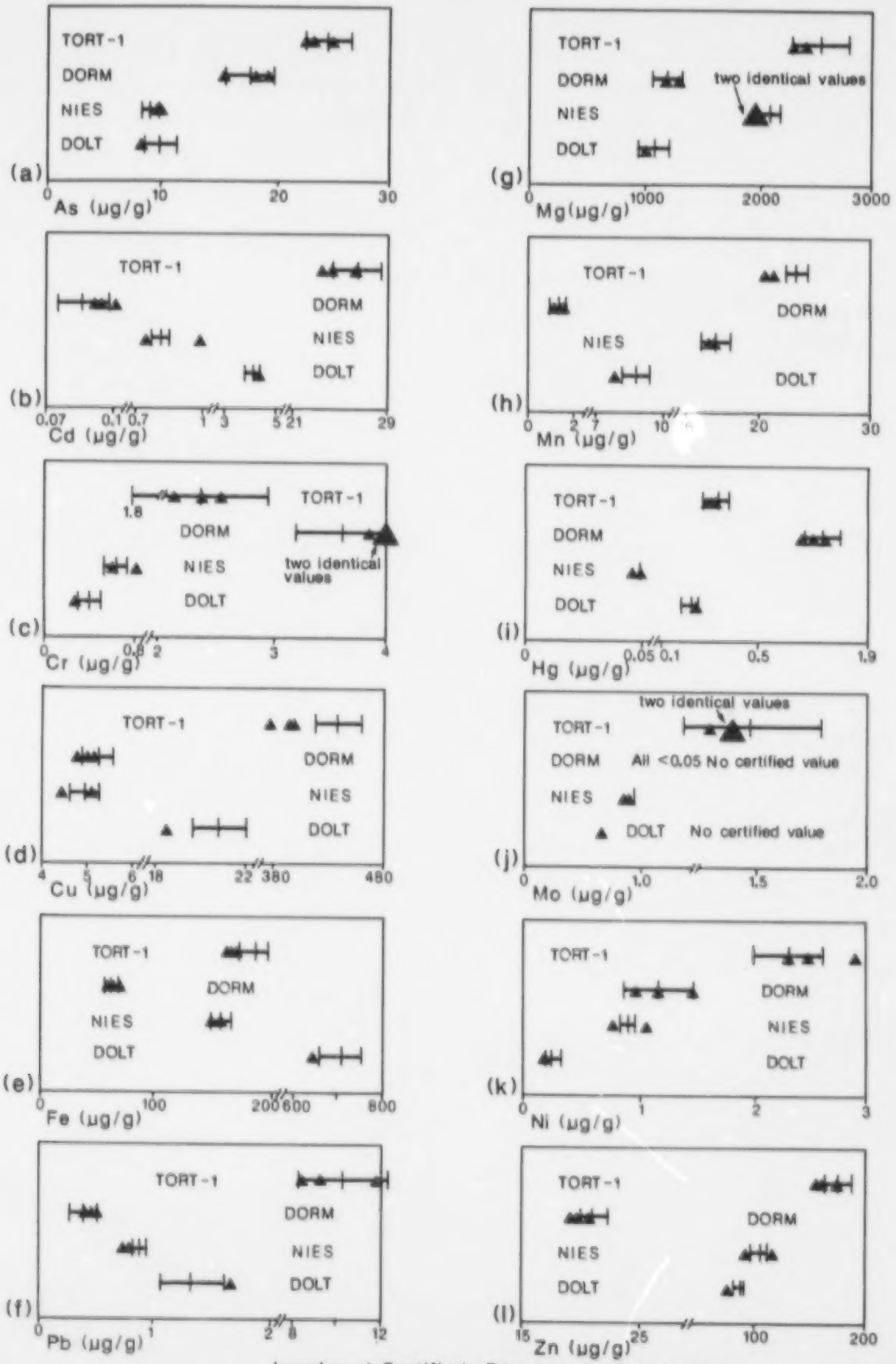

FIGURE 2 ACCURACY DATA FOR TISSUES - 1989

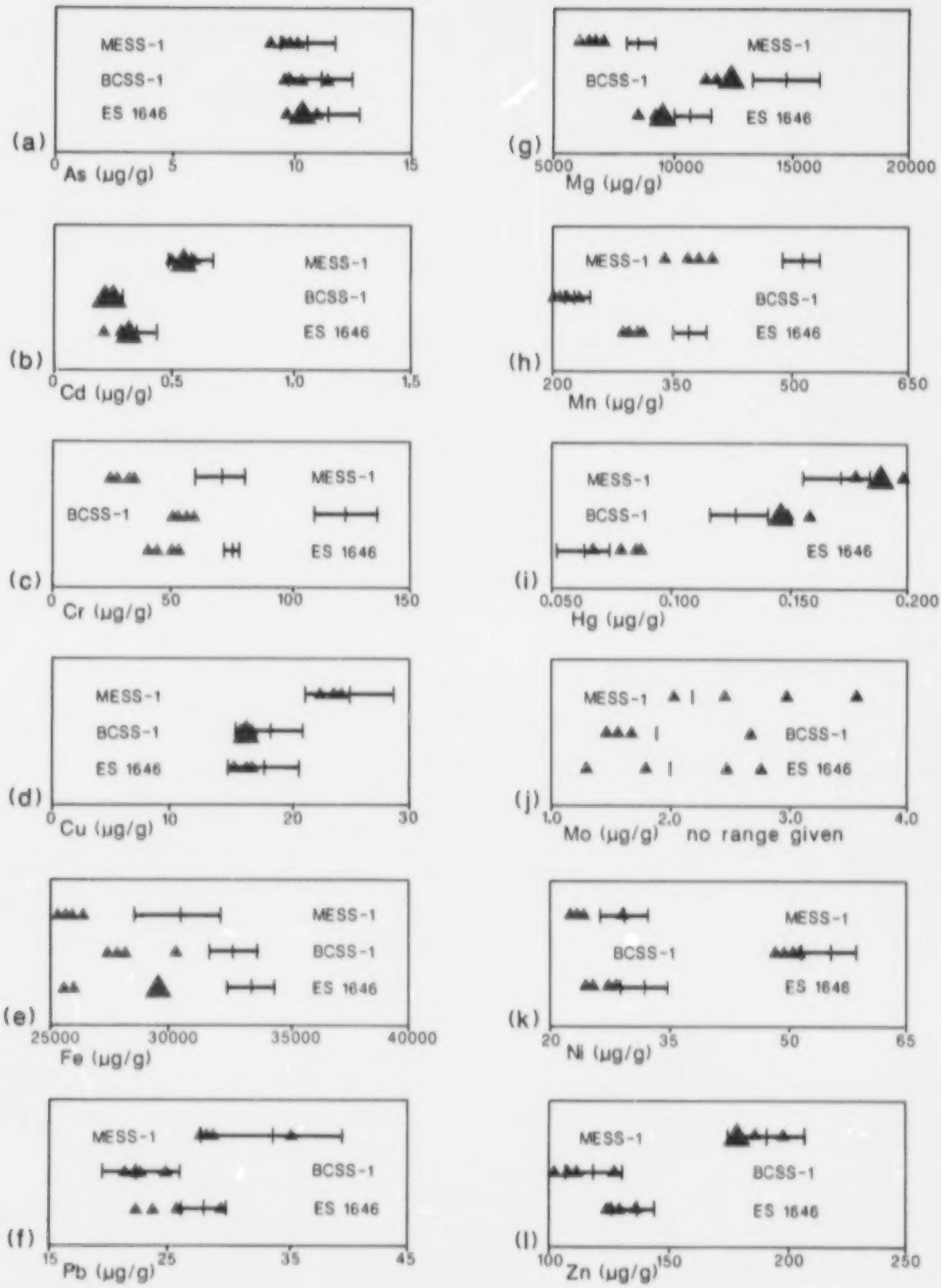

FIGURE 3 ACCURACY DATA FOR SEDIMENTS - 1989 SURVEYS

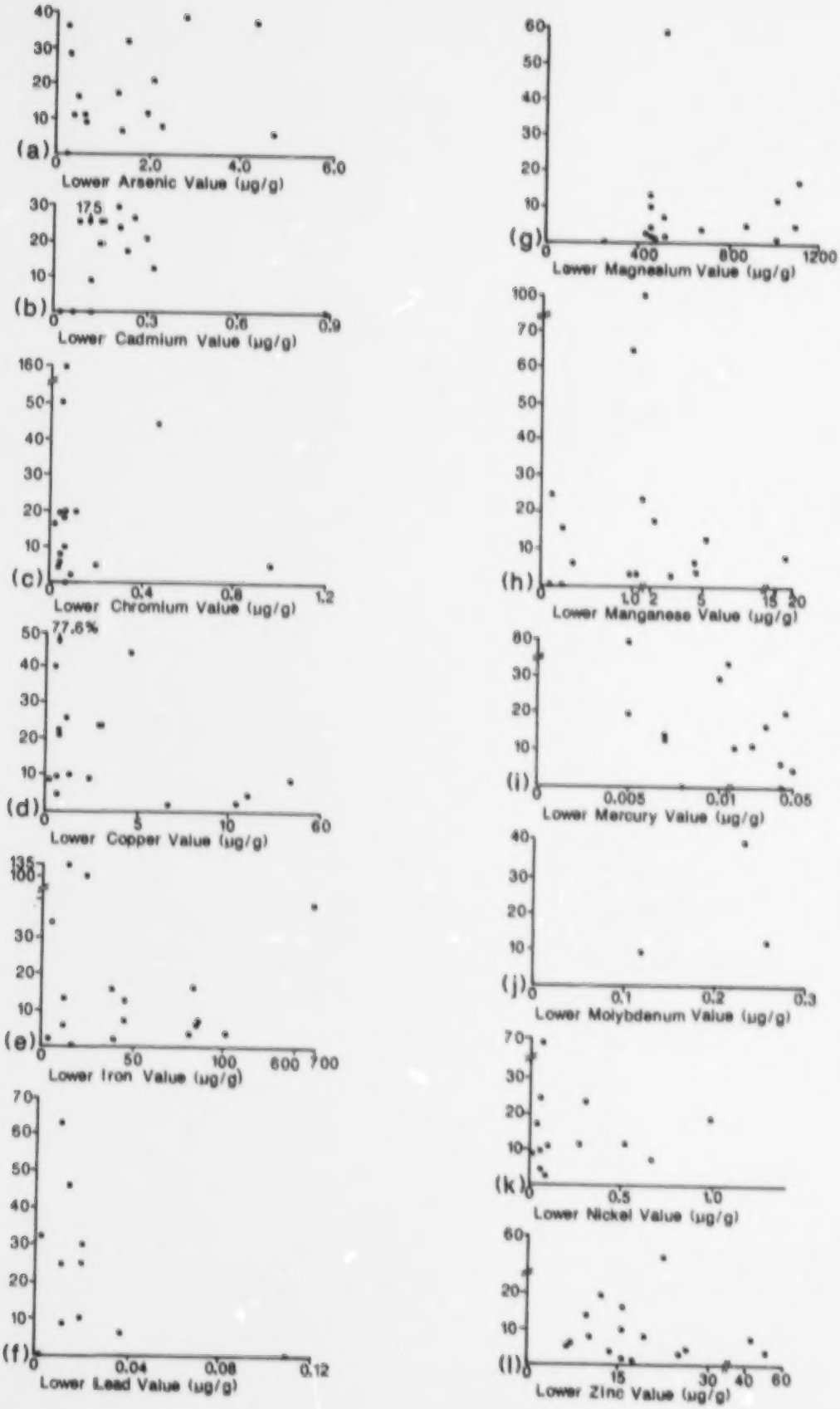

FIGURE 4 COMPARISON OF DUPLICATE ANALYSES FOR TISSUES

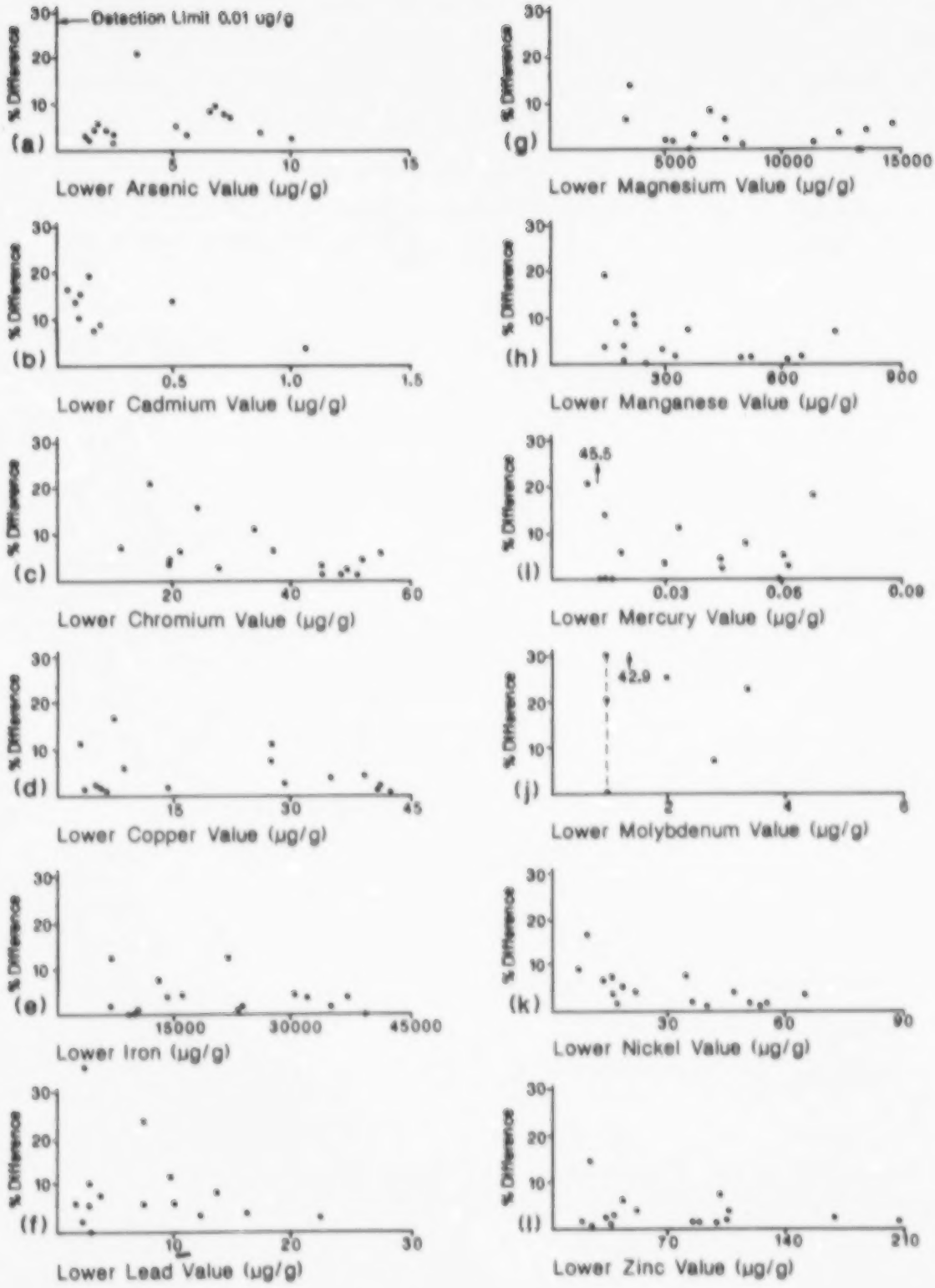

FIGURE 5 COMPARISON OF DUPLICATE ANALYSES FOR SEDIMENTS

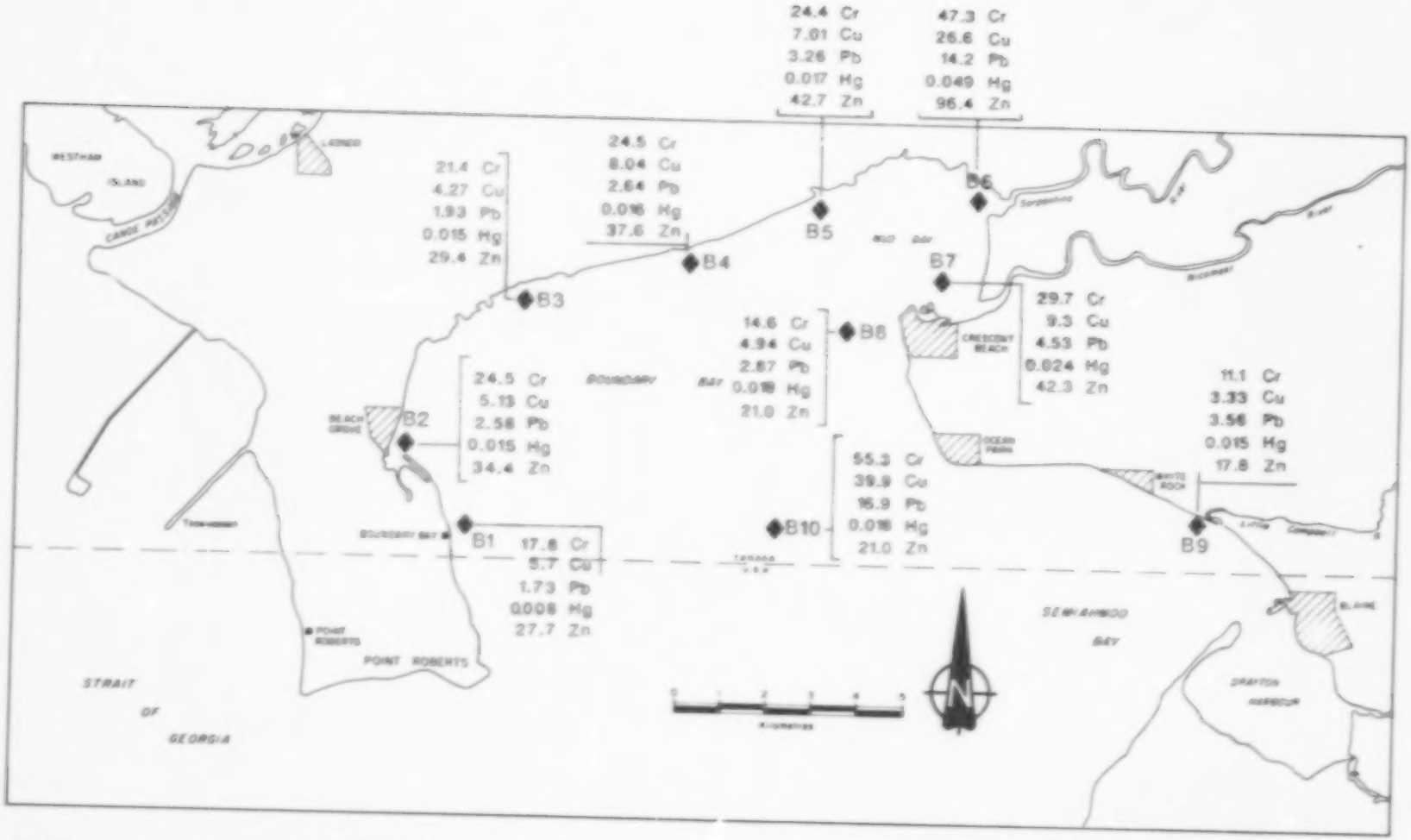

FIGURE 6 MEAN METAL CONCENTRATIONS (µg/g-dry) IN BOUNDARY BAY SEDIMENTS

TABLE 1
METAL CONCENTRATIONS (µg/g wet wt) IN SOFT-SHELLED CLAMS (M. ARENARIA)
SITE B-1 (n=7)

METAL	MAXIMUM	MINIMUM	MEAN	STD. DEV.
ARSENIC	5.01	1.55	2.77	1.46
CADMIUM	0.26	0.16	0.21	0.033
CHROMIUM	1	0.037	0.315	0.428
COPPER	2.73	1.14	1.71	0.542
IRON	95.8	45.2	85.3	44.1
LEAD	0.022	0.012	0.019	0.0044
MG	1310	557	840	277.2
MN	19	2.62	7.08	6.07
MERCURY	0.008	0.006	0.007	0.001
MO	0.13	<0.10	-	0.030
NICKEL	1.3	0.26	0.55	0.40
ZINC	18.5	7.68	11.5	3.79

METAL CONCENTRATIONS (µg/g wet wt) IN SOFT-SHELLED CLAMS (M. ARENARIA)
SITE B-5 (n=5)

METAL	MAXIMUM	MINIMUM	MEAN	STD. DEV.
ARSENIC	2.18	1.11	1.48	0.415
CADMIUM	0.2	0.08	0.12	0.045
CHROMIUM	0.58	0.44	0.50	0.052
COPPER	2.21	1.64	1.84	0.236
IRON	963	404	586	236.9
LEAD	0.14	0.072	0.101	0.026
MAGNESIUM	1250	1030	1118	81
MANGANESE	4.69	2.39	3.23	0.953
MERCURY	0.022	0.015	0.018	0.003
MOLYBDENUM	0.28	0.25	0.26	0.011
NICKEL	0.8	0.48	0.64	0.123
ZINC	14.2	10.7	11.9	1.397

TABLE 2
METAL CONCENTRATIONS (µg/g wet wt) IN CRABS
(C. MAGISTER)
SITE B-9 (n=7)

METAL	MAXIMUM	MINIMUM	MEAN	STD. DEV.
ARSENIC	4.96	0.32	3.24	1.67
CADMIUM	0.36	0.019	0.175	0.153
CHROMIUM	0.049	0.012	0.035	0.016
COPPER	11.4	6.24	9.25	2.317
IRON	13.3	5.64	9.79	2.57
LEAD	0.02	0.011	0.014	0.003
MG	648	418	507	77.83
MN	0.44	0.15	0.30	0.107
MERCURY	0.066	0.039	0.053	0.0099
MO	<0.05	<0.05	<0.05	-
NICKEL	0.068	0.02	0.046	0.019
ZINC	49.6	26.5	43.5	8.04

METAL CONCENTRATIONS (µg/g wet wt) IN CRABS
(C. MAGISTER)
SITE B-10 (n=8)

	MAXIMUM	MINIMUM	MEAN	Standard Deviation
ARSENIC	5.80	1.41	3.62	1.51
CADMIUM	1.18	0.006	0.300	0.469
CHROMIUM	0.088	0.019	0.055	0.021
COPPER	47.3	10.5	25.7	14.2
IRON	49.1	9.22	25.7	15.8
LEAD	0.072	0.013	0.031	0.024
MG	923	404	613	230.4
MN	1.21	0.19	0.51	0.40
MERCURY	0.089	0.019	0.049	0.021
MO	0.23	0.13	0.18	0.050
NICKEL	0.59	0.025	0.210	0.242
ZINC	53	9.52	34.5	18.2

TABLE 3
METAL CONCENTRATIONS IN WHOLE FISH AT SITE B-9

SHINER PERCH (N = 6)
(µg/g wet wt)

Metal	Maximum	Minimum	Mean	Standard Deviation
ARSENIC	1.33	0.29	0.52	0.401
CADMIUM	0.03	0.006	0.015	0.010
CHROMIUM	0.21	0.051	0.15	0.071
COPPER	1.07	0.64	0.80	0.162
IRON	146	29.9	76.1	42.7
LEAD	0.02	0.013	0.015	0.004
MG	1470	654	996	303.
MN	6.45	1.06	3.76	1.97
MERCURY	0.007	0.004	0.005	0.001
MO	<0.05	<0.05	<0.05	-
NICKEL	0.21	0.053	0.112	0.056
ZINC	19.5	15.9	17.9	1.51

THREESPINE STICKLEBACK (N=3)
(µg/g wet wt)

Metal	Maximum	Minimum	Mean	Standard Deviation
ARSENIC	0.45	0.39	0.42	0.03
CADMIUM	0.055	0.030	0.039	0.014
CHROMIUM	0.17	0.15	0.16	0.0115
COPPER	1.96	1.67	1.84	0.15
IRON	140	36.7	104	58.5
LEAD	0.032	0.019	0.026	0.009
MG	1093	706	881	196
MN	11.1	7.81	9.23	1.69
MERCURY	0.028	0.013	0.023	0.008
MO	0.07	0.07	0.07	-
NICKEL	0.17	0.055	0.13	0.066
ZINC	43.8	37.9	40.1	3.22

TABLE 3 (Continued)

STAGHORN SCULPIN (N =4)
(µg/g wet wt)

Metal	Maximum	Minimum	Mean	Standard Deviation
ARSENIC	0.45	0.36	0.41	0.037
CADMIUM	0.033	0.012	0.024	0.009
CHROMIUM	0.21	0.071	0.133	0.057
COPPER	1.19	0.6	1	0.28
IRON	113	12.1	52.2	43.2
LEAD	0.016	0.013	0.015	0.002
MG	616	458	504	74.9
MN	2.92	0.91	1.76	0.84
MERCURY	0.01	0.005	0.008	0.002
MO	<0.05	<0.05	<0.05	-
NICKEL	0.17	0.03	0.08	0.060
ZINC	15.8	10.3	13.6	2.34

TABLE 4

METAL CONCENTRATIONS IN WHOLE FISH AT SITE B-10
SNAKE PRICKLEBACK (N=5)
(µg/g wet wt)

Metal	Maximum	Minimum	Mean	Standard Deviation
ARSENIC	0.48	0.42	0.47	0.026
CADMIUM	0.019	0.012	0.014	0.003
CHROMIUM	0.091	0.033	0.057	0.024
COPPER	0.94	0.7	0.85	0.092
IRON	91.6	70.1	80.4	9.24
LEAD	0.055	0.036	0.044	0.009
MG	561	468	493	38.8
MN	1.24	1	1.1	0.094
MERCURY	0.023	0.005	0.013	0.007
MO	<0.05	<0.05	<0.05	-
NICKEL	0.13	0.086	0.099	0.018
ZINC	19.4	15.4	17.6	1.73

BUTTERSOLE (N=5)
(µg/g wet wt)

Metal	Maximum	Minimum	Mean	Standard Deviation
ARSENIC	1.04	0.67	0.88	0.139
CADMIUM	0.014	0.005	0.009	0.047
CHROMIUM	0.19	0.068	0.116	0.047
COPPER	0.83	0.47	0.65	0.14
IRON	125	49.1	70.3	31.5
LEAD	0.075	0.04	0.063	0.014
MG	585	401	463	73.8
MN	2.93	1.18	1.78	0.709
MERCURY	0.013	0.009	0.010	0.002
MO	<0.05	<0.05	<0.05	-
NICKEL	0.19	0.068	0.111	0.047
ZINC	14.6	11.1	12.2	1.39

TABLE 4 (Continued)
PACIFIC SANDAB (N=4)
(µg/g wet wt)

Metal	Maximum	Minimum	Mean	Standard Deviation
ARSENIC	0.67	0.62	0.63	0.025
CADMIUM	0.05	0.005	0.030	0.019
CHROMIUM	0.18	0.074	0.116	0.050
COPPER	1.32	0.29	0.77	0.43
IRON	144	40.2	75.3	48.5
LEAD	0.11	0.026	0.057	0.037
MG	540	362	437	77.8
MN	2.98	1.24	2.02	0.78
MERCURY	0.019	0.006	0.013	0.006
MO	<0.05	<0.05	<0.05	-
NICKEL	0.21	0.086	0.134	0.053
ZINC	22.3	10	16.6	5.59

STARRY FLOUNDER (N=5)
MUSCLE TISSUES (µg/g wet wt)

Metal	Maximum	Minimum	Mean	Standard Deviation
ARSENIC	1.63	0.66	1.02	0.42
CADMIUM	0.006	0.006	0.006	0.0
CHROMIUM	0.11	0.034	0.068	0.029
COPPER	0.92	0.19	0.368	0.031
IRON	81.6	3.84	20.8	34.0
LEAD	0.23	0.02	0.022	0.002
MG	423	240	290	75.8
MN	2.42	0.11	0.59	1.02
MERCURY	0.094	0.035	0.054	0.023
MO	<0.05	<0.05	<0.05	-
NICKEL	0.14	0.034	0.063	0.044
ZINC	23.9	6.45	11.0	7.3

TABLE 4
(Continued)

STARRY FLOUNDER (N=3)
LIVERS
(µg/g wet wt)

Metal	Maximum	Minimum	Mean	Standard Deviation
ARSENIC	1.43	0.89	1.12	0.28
CADMIUM	1.05	0.77	0.91	0.14
CHROMIUM	0.038	0.029	0.035	0.005
COPPER	5.98	4.89	5.61	0.63
IRON	251	114	175	69.6
LEAD	0.15	0.065	0.12	0.046
MG	322	265	285	32.1
MN	0.8	0.61	0.7	0.095
MERCURY	0.065	0.036	0.05	0.015
MO	0.082	0.053	0.069	0.015
NICKEL	0.25	0.11	0.16	0.08
ZINC	28.7	28.3	28.5	0.2

TABLE 5

METAL CONCENTRATIONS IN CRABS (C. MAGISTER) FROM BURRARD INLET

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
ARSENIC					
PACIFIC ENVIRONMENT INSTITUTE					
May 1985	3	95	33	64	31
BOULDER ROCK					
May 1985	3	20	8	12.7	6.4
BURRARD YARROWS					
May 1985	1	19	-	-	-
October 1985	6	31	12	22	7
January 1986	6	30	15	19	6
CATES PARK					
May 1985	3	20	11	15	5
CENTRE					
January 1986	6	25	13	19	4
CHEVRON					
May 1985	1	14	-	-	-
COAL HARBOUR					
May 1985	4	24	8	20	8
October 1985	5	21	14	19	3
January 1986	6	16	9	13	2
IOCO					
January 1986	5	23	10	15	5
PORT MOODY					
May 1985	2	5	<4	-	-
October 1985	6	25	<4	12	9
January 1986	5	23	14	18	4
STERLING					
May 1985	2	21	16	19	-
October 1985	6	37	21	28	6
VANTERM					
May 1985	2	33	31	32	-
January 1986	5	23	14	18	4

TABLE 5
Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
CADMIUM					
PACIFIC ENVIRONMENT INSTITUTE					
May 1985	3	0.12	0.07	0.09	0.03
BOULDER ROCK					
May 1985	3	<0.2	<0.2	<0.2	-
BURRARD YARROWS					
May 1985	1	<0.04	-	-	-
October 1985	6	0.09	<0.04	0.05	0.02
January 1986	6	0.10	<0.04	0.06	0.03
CATES PARK					
May 1985	3	0.56	0.22	0.37	0.17
CENTRE					
January 1986	6	0.10	<0.04	0.06	0.03
CHEVRON					
May 1985	1	0.46	-	-	-
COAL HARBOUR					
May 1985	4	0.51	0.26	0.34	0.12
October 1985	5	<0.04	<0.04	<0.04	-
January 1986	6	0.09	<0.04	0.06	0.02
IOCO					
January 1986	5	<0.04	<0.04	<0.04	-
PORT MOODY					
May 1985	2	0.2	0.18	0.19	-
October 1985	6	0.08	<0.04	0.06	0.02
January 1986	5	0.06	0.05	0.06	0.01
STERLING					
May 1985	2	<0.04	<0.04	<0.04	-
October 1985	6	0.06	<0.04	0.05	0.01
VANTERM					
May 1985	2	0.16	<0.4	0.10	-

TABLE 5
Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
CHROMIUM					
PACIFIC ENVIRONMENT INSTITUTE					
May 1985	3	0.9	<0.4	0.6	0.3
BOULDER ROCK					
May 1985	3	0.6	0.5	0.6	0.1
BURRARD YARROWS					
May 1985	1	0.4	-	-	-
October 1985	6	0.9	0.8	0.8	0.1
January 1986	6	0.7	0.5	0.6	0.1
CATES PARK					
May 1985	3	0.7	0.6	0.6	0.1
CENTRE					
January 1986	6	0.8	<0.4	0.6	0.2
CHEVRON					
May 1985	1	2.1	-	-	-
COAL HARBOUR					
May 1985	4	1.0	0.7	0.8	0.1
October 1985	5	0.9	0.6	0.8	0.1
January 1986	6	1.1	0.6	0.8	0.2
IOCO					
January 1986	5	0.8	0.5	0.6	0.1
PORT MOODY					
May 1985	2	0.6	0.6	0.6	-
October 1985	6	1.2	0.4	0.8	0.3
January 1986	5	0.7	0.4	0.5	0.1
STERLING					
May 1985	2	0.5	0.4	0.45	-
October 1985	6	0.8	0.6	0.7	0.1
VANTERM					
May 1985	2	0.7	0.7	0.7	-

TABLE 5
Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
COPPER					
PACIFIC ENVIRONMENT INSTITUTE					
May 1985	3	45.9	27.3	35.8	9.4
BOULDER ROCK					
May 1985	3	55.9	44	48.7	6.3
BURRARD YARROWS					
May 1985	1	32.8	-	-	-
October 1985	6	89.9	35.2	54.7	23.7
January 1986	6	122	32.9	64.5	34.6
CATES PARK					
May 1985	3	71.3	37.1	52	17.5
CENTRE					
January 1986	6	81.6	46	57.8	13
CHEVRON					
May 1985	1	56.2	-	-	-
COAL HARBOUR					
May 1985	4	57.5	19.9	33.4	16.7
October 1985	5	99.8	58.5	75.9	16.9
January 1986	6	125	35.9	65.5	31.6
IOCO					
January 1986	5	39.1	22	29	7.7
PORT MOODY					
May 1985	2	38.6	37.3	38	-
October 1985	6	67.5	25.5	46.3	16.2
January 1986	5	75.1	24.2	48.9	19.4
STERLING					
May 1985	2	48.4	28.2	38.3	-
October 1985	6	79.1	39.4	58.5	14.9
VANTERM					
May 1985	2	66.1	42.2	54.2	-

TABLE 5
Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
IRON					
PACIFIC ENVIRONMENT INSTITUTE					
May 1985	3	121	75.5	96.9	22.9
BOULDER ROCK					
May 1985	3	120	73.9	90.4	25.7
BURRARD YARROWS					
May 1985	1	46.1	-	-	-
October 1985	6	111	38.9	60.0	26.5
January 1986	6	65.9	32.9	47.6	11.7
CATES PARK					
May 1985	3	57	49	53	4
CENTRE					
January 1986	6	49.1	23.1	38.7	9.8
CHEVRON					
May 1985	1	33.3	-	-	-
COAL HARBOUR					
May 1985	4	163	31.3	80.2	59.4
October 1985	5	68.6	33	52.1	13.8
January 1986	6	234	60.6	115.3	70.1
IOCO					
January 1986	5	256	63.8	103.2	85.4
PORT MOODY					
May 1985	2	36.5	33.7	35.1	-
October 1985	6	83.8	50.3	65.5	12.1
January 1986	5	98.2	43.3	59.9	22.5
STERLING					
May 1985	2	31	27.5	29.3	-
October 1985	6	116	31.2	59.5	29
VANTERM					
May 1985	2	263	43.5	153.3	-

TABLE 5
Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
MERCURY					
BURRARD YARROWS					
May 1985	1	0.11	-	-	-
October 1985	6	0.53	0.16	0.31	0.16
January 1986	6	0.79	0.35	0.57	0.22
CATES PARK					
May 1985	3	1.02	<0.02	0.36	0.57
CENTRE					
January 1986	6	0.95	0.27	0.56	0.29
CHEVRON					
May 1985	1	0.28	-	-	-
COAL HARBOUR					
May 1985	4	0.36	0.17	0.25	0.09
October 1985	5	0.66	0.21	0.37	0.2
January 1986	6	0.78	0.37	0.54	0.18
IOCO					
January 1986	5	0.80	0.06	0.25	0.31
PORT MOODY					
May 1985	2	0.2	0.1	0.15	-
October 1985	6	0.39	0.08	0.20	0.15
January 1986	5	0.94	0.12	0.52	0.33
STERLING					
May 1985	2	0.23	0.18	0.21	-
October 1985	6	0.99	0.32	0.58	0.27
VANTERM					
May 1985	2	1.61	0.94	1.28	-

TABLE 5
Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM	MEAN	STD. DEV.
			(µg/g dry wt)		
MAGNESIUM					
PACIFIC ENVIRONMENT INSTITUTE					
May 1985	3	1700	1530	1633	91
BOULDER ROCK					
May 1985	3	1700	1480	1576.7	112
BURRARD YARROWS					
May 1985	1	1490	-	-	-
October 1985	6	1990	1590	1720	143
January 1986	6	2440	1380	1785	385
CATES PARK					
May 1985	3	2760	1750	2133	547
CENTRE					
January 1986	6	2110	1690	1927	160
CHEVRON					
May 1985	1	1860	-	-	-
COAL HARBOUR					
May 1985	4	2250	1250	1653	436
October 1985	5	2600	1310	1692	529
January 1986	6	1850	1390	1640	188
IOCO					
January 1986	5	2230	1310	1858	378
PORT MOODY					
May 1985	2	1390	1380	1385	-
October 1985	6	2370	1430	1915	399
January 1986	5	1920	1440	1650	214
STERLING					
May 1985	2	2220	1430	1825	559
October 1985	6	1480	1190	1343	98
VANTERM					
May 1985	2	2800	1400	2125	-

TABLE 5
Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
MANGANESE					
PACIFIC ENVIRONMENT INSTITUTE					
May 1985	3	4.31	1.61	2.77	1.39
BOULDER ROCK					
May 1985	3	2.6	1.2	1.8	0.7
BURRARD YARROWS					
May 1985	1	1.13	-	-	-
October 1985	6	1.52	0.92	1.28	0.25
January 1986	6	1.55	1.06	1.27	0.18
CATES PARK					
May 1985	3	1.4	1.3	1.4	0.1
CHEVRON					
May 1985	1	1.2	-	-	-
CENTRE					
January 1986	6	1.28	0.96	1.16	0.12
COAL HARBOUR					
May 1985	4	2.13	1.21	1.59	0.45
October 1985	5	1.43	0.87	1.12	0.23
January 1986	6	2.87	1.28	1.97	0.64
IOCO					
January 1986	5	3.03	0.97	1.82	0.78
PORT MOODY					
May 1985	2	0.95	0.88	0.92	-
October 1985	6	1.60	0.83	1.28	0.25
January 1986	5	1.98	0.85	1.20	0.45
STERLING					
May 1985	2	1.06	0.98	1.02	-
October 1985	6	1.53	0.74	1.20	0.29
VANTERM					
May 1985	2	2.42	0.95	1.69	-

TABLE 5
Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM	MEAN	STD. DEV.
			(µg/g dry wt)		
MOLYBDENUM					
PACIFIC ENVIRONMENT INSTITUTE					
May 1985	3	<0.4	<0.4	<0.4	-
BOULDER ROCK					
May 1985	3	<0.4	<0.4	<0.4	-
BURRARD YARROWS					
May 1985	1	<0.4	-	-	-
October 1985	6	0.6	<0.4	0.4	0.1
January 1986	6	<0.4	<0.4	<0.4	-
CATES PARK					
May 1985	3	<0.4	<0.4	<0.4	-
CENTRE					
January 1986	6	<0.4	<0.4	<0.4	-
CHEVRON					
May 1985	1	<0.5	-	-	-
COAL HARBOUR					
May 1985	4	0.8	<0.4	0.7	0.1
October 1985	5	0.8	<0.4	0.5	0.2
January 1986	6	<0.4	<0.4	<0.4	-
IOCO					
January 1986	5	<0.4	<0.4	<0.4	-
PORT MOODY					
May 1985	2	0.4	<0.4	-	-
October 1985	6	0.7	<0.4	0.5	0.2
January 1986	5	<0.4	<0.4	<0.4	-
STERLING					
May 1985	2	<0.4	<0.4	<0.4	-
October 1985	6	0.6	<0.4	0.4	0.1
VANTERM					
May 1985	2	0.5	<0.4	-	-

TABLE 5
Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
NICKEL					
PACIFIC ENVIRONMENT INSTITUTE					
May 1985	3	<2	<2	<2	-
BOULDER ROCK					
May 1985	3	<2	<2	<2	-
BURRARD YARROWS					
May 1985	1	<2	-	-	-
October 1985	6	<2	<2	<2	-
January 1986	6	<2	<2	<2	-
CATES PARK					
May 1985	3	<2	<2	<2	-
CENTRE					
January 1986	6	<2	<2	<2	-
CHEVRON					
May 1985	1	<2	-	-	-
COAL HARBOUR					
May 1985	4	<2	<2	<2	-
October 1985	5	<2	<2	<2	-
January 1986	6	<2	<2	<2	-
IOCO					
January 1986	5	<2	<2	<2	-
PORT MOODY					
May 1985	2	<2	<2	<2	-
October 1985	6	<3	<2	-	-
January 1986	5	2	<2	<2	-
STERLING					
May 1985	2	<2	<2	<2	-
October 1985	6	<2	<2	<2	-
VANTERM					
May 1985	2	<2	<2	<2	-

TABLE 5
Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
LEAD					
PACIFIC ENVIRONMENT INSTITUTE					
May 1985	3	0.16	0.08	0.12	0.04
BOULDER ROCK					
May 1985	3	0.31	0.17	0.25	0.07
BURRARD YARROWS					
May 1985	1	0.1	-	-	-
October 1985	6	0.30	<0.08	0.18	0.08
January 1986	6	0.44	<0.08	0.20	0.13
CATES PARK					
May 1985	3	2.00	1.66	1.81	0.17
CENTRE					
January 1986	6	0.78	0.68	0.74	0.04
CHEVRON					
May 1985	1	2.7	-	-	-
COAL HARBOUR					
May 1985	4	2.03	1.26	1.58	0.34
October 1985	5	0.32	0.13	0.19	0.08
January 1986	6	1.28	<0.08	0.49	0.51
IOCO					
January 1986	5	0.63	0.56	0.60	0.03
PORT MOODY					
May 1985	2	1.37	0.97	1.17	-
October 1985	6	0.24	<0.08	0.18	0.06
January 1986	5	0.77	0.54	0.64	0.10
STERLING					
May 1985	2	0.20	0.09	0.15	-
October 1985	6	0.26	0.10	0.18	0.06
VANTERM					
May 1985	2	0.37	<0.08	0.23	-

TABLE 5
Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
ZINC					
PACIFIC ENVIRONMENT INSTITUTE					
May 1985	3	216	190	207	14.7
BOULDER ROCK					
May 1985	3	209	155	179.7	27.3
BURRARD YARROWS					
May 1985	1	224	-	-	-
October 1985	6	210	151	181	24
January 1986	6	291	163	217	55
CATES PARK					
May 1985	3	195	179	186.7	8
CENTRE					
January 1986	6	270	145	204	44
CHEVRON					
May 1985	1	122	-	-	-
COAL HARBOUR					
May 1985	4	196	179	184	8
October 1985	5	233	181	203	23
January 1986	6	266	185	214	35
IOCO					
January 1986	5	232	143	180	34
PORT MOODY					
May 1985	2	149	146	147.5	-
October 1985	6	201	162	180	17
January 1986	5	277	202	233	32
STERLING					
May 1985	2	165	161	163	-
October 1985	6	213	160	182	19
VANTERM					
May 1985	2	296	155	225.5	-

TABLE 6

METAL CONCENTRATIONS IN SELECTED FISH SPECIES FROM BURRARD INLET

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
ARSENIC					
BURRARD YARROWS					
May 1985					
SANDAB SOLE	1	14	-	-	-
STARRY FLOUNDER	1	6	-	-	-
COAL HARBOUR					
STARRY FLOUNDER	2	24	<4	14	14
PORT MOODY					
STARRY FLOUNDER	2	18	15	17	2
VANTERM					
STARRY FLOUNDER	1	5	-	-	-
January 1986					
CENTRE					
SHINER PERCH	3	7	4	5	2
CADMIUM					
BURRARD YARROWS					
May 1985					
SANDAB SOLE	1	<0.04	-	-	-
STARRY FLOUNDER	1	0.07	-	-	-
COAL HARBOUR					
STARRY FLOUNDER	2	0.28	0.23	0.26	0.04
PORT MOODY					
STARRY FLOUNDER	2	0.20	0.17	0.19	0.02
VANTERM					
STARRY FLOUNDER	1	<0.04	-	-	-
January 1986					
CENTRE					
SHINER PERCH	3	<0.04	<0.04	<0.04	-

TABLE 6 Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
CHROMIUM					
BURRARD YARROWS					
May 1985					
SANDAB SOLE	1	0.4	-	-	-
STARRY FLOUNDER	1	0.5	-	-	-
COAL HARBOUR					
STARRY FLOUNDER	2	1.3	1.0	1.2	0.2
PORT MOODY					
STARRY FLOUNDER	2	0.7	0.5	0.6	0.1
VANTERM					
STARRY FLOUNDER	1	0.7	-	-	-
January 1986					
CENTRE					
SHINER PERCH	3	1.0	0.5	0.7	0.3
COPPER					
BURRARD YARROWS					
May 1985					
SANDAB SOLE	1	<0.4	-	-	-
STARRY FLOUNDER	1	<0.4	-	-	-
COAL HARBOUR					
STARRY FLOUNDER	2	2.1	1.3	1.7	0.6
PORT MOODY					
STARRY FLOUNDER	2	1.5	1.1	1.3	0.3
VANTERM					
STARRY FLOUNDER	1	4	-	-	-
January 1986					
CENTRE					
SHINER PERCH	3	3.9	1.5	2.5	1.2

TABLE 6 Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
IRON					
BURRARD YARROWS					
May 1985					
SANDAB SOLE	1	9.7	-	-	-
STARRY FLOUNDER	1	34.1	-	-	-
COAL HARBOUR					
STARRY FLOUNDER	2	126	25.2	75.6	71.3
PORT MOODY					
STARRY FLOUNDER	2	40.5	21.9	31.2	13.2
VANTERM					
STARRY FLOUNDER	1	69.1	-	-	-
January 1986					
CENTRE					
SHINER PERCH	3	27.1	15.3	21.9	6.0
MERCURY					
BURRARD YARROWS					
May 1985					
SANDAB SOLE	1	0.37	-	-	-
STARRY FLOUNDER	1	0.54	-	-	-
COAL HARBOUR					
STARRY FLOUNDER	2	1.49	0.43	0.96	0.75
PORT MOODY					
STARRY FLOUNDER	2	0.24	0.20	0.22	0.03
VANTERM					
STARRY FLOUNDER	1	1.02	-	-	-
January 1986					
CENTRE					
SHINER PERCH	3	0.45	0.14	0.29	0.16

TABLE 6 Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
MAGNESIUM					
May 1985					
SANDAB SOLE	1	1480	-	-	-
STARRY FLOUNDER	1	1250	-	-	-
COAL HARBOUR					
STARRY FLOUNDER	2	1440	1220	1330	156
PORT MOODY					
STARRY FLOUNDER	2	1310	1000	1155	219
VANTERM					
STARRY FLOUNDER	1	1260	-	-	-
January 1986					
CENTRE					
SHINER PERCH	3	1510	1370	1460	78
MANGANESE					
May 1985					
SANDAB SOLE	1	0.42	-	-	-
STARRY FLOUNDER	1	0.78	-	-	-
COAL HARBOUR					
STARRY FLOUNDER	2	6.49	0.86	3.68	3.98
PORT MOODY					
STARRY FLOUNDER	2	0.95	0.58	0.77	0.26
VANTERM					
STARRY FLOUNDER	1	1.45	-	-	-
January 1986					
CENTRE					
SHINER PERCH	3	2.09	1.41	1.73	0.34

TABLE 6 Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
MOLYBDENUM					
May 1985					
SANDAB SOLE	1	<0.4	-	-	-
STARRY FLOUNDER	1	<0.4	-	-	-
COAL HARBOUR					
STARRY FLOUNDER	2	0.4	<0.4	-	-
PORT MOODY					
STARRY FLOUNDER	2	<0.4	<0.4	<0.4	-
VANTERM					
STARRY FLOUNDER	1	<0.4	-	-	-
January 1986					
CENTRE					
SHINER PERCH	3	0.5	<0.4	0.4	0.1
NICKEL					
May 1985					
SANDAB SOLE	1	<2	-	-	-
STARRY FLOUNDER	1	<2	-	-	-
COAL HARBOUR					
STARRY FLOUNDER	2	<2	<2	<2	-
PORT MOODY					
STARRY FLOUNDER	2	<2	<2	<2	-
VANTERM					
STARRY FLOUNDER	1	<2	-	-	-
January 1986					
CENTRE					
SHINER PERCH	3	2	<2	2	-

TABLE 6 Continued

METAL/ STATION	NO.OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD. DEV.
LEAD					
May 1985					
SANDAB SOLE	1	<0.08	-	-	-
STARRY FLOUNDER	1	<0.08	-	-	-
COAL HARBOUR					
STARRY FLOUNDER	2	1.29	1.13	1.21	0.11
PORT MOODY					
STARRY FLOUNDER	2	1.43	1.07	1.25	0.25
VANTERM					
STARRY FLOUNDER	1	0.16	-	-	-
January 1986					
CENTRE					
SHINER PERCH	3	<0.08	<0.08	<0.08	-
ZINC					
May 1985					
SANDAB SOLE	1	13.1	-	-	-
STARRY FLOUNDER	1	28.7	-	-	-
COAL HARBOUR					
STARRY FLOUNDER	2	64.7	31.1	47.9	23.8
PORT MOODY					
STARRY FLOUNDER	2	24.8	17.1	21.0	5.4
VANTERM					
STARRY FLOUNDER	1	47.2	-	-	-
January 1986					
CENTRE					
SHINER PERCH	3	26.4	19.3	22.5	3.6

Data in this table are from Goyette and Boyd, 1989.

TABLE 7

SUMMARY OF METAL CONCENTRATIONS IN BOUNDARY BAY SEDIMENTS

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN	STANDARD DEVIATION
ARSENIC					
B-1	5	2.09	1.86	2.01	0.089
B-2	5	2.86	1.16	2.14	0.670
B-3	5	1.77	1.45	1.58	0.135
B-4	5	2.92	2.23	2.63	0.259
B-5	5	3.38	2.21	3.01	0.465
B-6	5	8.54	6.27	7.08	0.879
B-7	5	5.17	2.44	3.53	1.019
B-8	5	2.03	1.30	1.50	0.302
B-9	5	2.57	1.67	1.98	0.355
B-10	5	10.6	9.44	10.1	0.464
CADMIUM					
B-1	5	<0.1	<0.1	<0.1	-
B-2	5	0.29	0.11	0.17	0.077
B-3	5	0.16	0.12	0.14	0.015
B-4	5	0.17	0.11	0.14	0.026
B-5	5	0.14	<0.1	<0.1+	-
B-6	5	0.17	<0.1	<0.1+	-
B-7	5	<0.1	<0.1	<0.1	-
B-8	5	<0.1	<0.1	<0.1	-
B-9	5	0.13	<0.1	<0.1+	-
B-10	5	1.12	0.37	0.63	0.288

+ MEDIAN VALUE

TABLE 7 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN	STANDARD DEVIATION
CHROMIUM					
B-1	5	19.4	14.9	17.8	2.08
B-2	5	28.5	19.8	24.5	3.41
B-3	5	28.3	16.0	21.4	5.32
B-4	5	27.5	22.3	24.5	2.17
B-5	5	26.4	22.9	24.4	1.61
B-6	5	50.4	44.1	47.3	2.55
B-7	5	34.3	23.2	29.7	4.20
B-8	5	12.3	9.91	11.1	0.981
B-9	5	19.1	10.9	14.6	3.30
B-10	5	58.1	50.2	55.3	3.11
COPPER					
B-1	5	8.81	4.39	5.70	1.82
B-2	5	6.71	3.40	5.13	1.30
B-3	5	5.20	3.34	4.27	0.72
B-4	5	8.88	7.23	8.04	0.78
B-5	5	7.67	6.13	7.01	0.66
B-6	5	28.8	24.6	26.6	1.85
B-7	5	13.8	6.25	9.30	2.75
B-8	5	4.38	2.83	3.33	0.61
B-9	5	5.77	4.12	4.94	0.77
B-10	5	41.9	38.9	39.9	1.18
IRON					
B-1	5	12800	9800	11280	1160
B-2	5	12100	8000	10420	1587
B-3	5	10800	8100	9400	1160
B-4	5	14500	12000	13160	1141
B-5	5	12400	10600	11560	716
B-6	5	23500	19700	21680	1642
B-7	5	16300	10200	12740	2230
B-8	5	8200	6600	7200	604
B-9	5	11100	7800	9140	1514
B-10	5	33300	30900	32060	934

TABLE 7 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN	STANDARD DEVIATION
LEAD					
B-1	5	1.92	1.51	1.73	0.17
B-2	5	3.50	1.74	2.58	0.79
B-3	5	2.90	1.20	1.93	0.73
B-4	5	2.90	2.35	2.64	0.27
B-5	5	3.50	3.00	3.26	0.23
B-6	5	15.1	12.3	14.2	1.16
B-7	5	7.45	1.71	4.53	2.44
B-8	5	4.12	2.62	3.56	0.58
B-9	5	4.13	2.02	2.87	0.87
B-10	5	18.6	15.2	16.9	1.39
MAGNESIUM					
B-1	5	6000	4900	5360	467
B-2	5	6100	4000	5240	802
B-3	5	6400	4400	5300	784
B-4	5	6900	6000	6540	416
B-5	5	6000	5000	5500	430
B-6	5	11300	9300	10200	831
B-7	5	7500	5300	6500	784
B-8	5	3600	3000	3220	249
B-9	5	5300	3700	4360	733
B-10	5	15400	13500	14720	740
MANGANESE					
B-1	5	242	181	201	24.1
B-2	5	200	161	184	14.6
B-3	5	187	141	161	18.5
B-4	5	239	207	224	13.8
B-5	5	190	176	184	5.40
B-6	5	300	257	279	16.7
B-7	5	213	172	195	16.3
B-8	5	141	119	131	9.71
B-9	5	198	148	169	22.3
B-10	5	381	354	367	12.0

TABLE 7 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN	STANDARD DEVIATION
MERCURY					
B-1	5	0.009	0.006	0.008	0.0013
B-2	5	0.018	0.011	0.015	0.0033
B-3	5	0.020	0.011	0.015	0.0036
B-4	5	0.020	0.012	0.016	0.0032
B-5	5	0.019	0.015	0.017	0.0016
B-6	5	0.054	0.044	0.049	0.0044
B-7	5	0.029	0.018	0.024	0.0041
B-8	5	0.022	0.010	0.015	0.0044
B-9	5	0.021	0.013	0.018	0.0029
B-10	5	0.095	0.069	0.078	0.0105
MOLYBDENUM					
B-1	5	<1.0	<1.0	<1.0	-
B-2	5	<1.0	<1.0	<1.0	-
B-3	5	<1.0	<1.0	<1.0	-
B-4	5	1.0	<1.0	<1.0+	-
B-5	5	<1.0	<1.0	<1.0	-
B-6	5	2.20	<1.0	1.83	0.44
B-7	5	<1.0	<1.0	<1.0	-
B-8	5	<1.0	<1.0	<1.0	-
B-9	5	<1.0	<1.0	<1.0	-
B-10	5	1.50	<1.0	<1.0+	-
NICKEL					
B-1	5	15.3	11.3	12.9	2.11
B-2	5	16.0	10.3	13.5	2.36
B-3	5	14.6	10.7	12.6	1.64
B-4	5	20.5	15.2	17.4	2.05
B-5	5	17.6	14.3	16.3	1.36
B-6	5	36.4	30.1	33.0	2.61
B-7	5	22.2	15.0	18.6	2.55
B-8	5	8.16	6.27	6.92	0.73
B-9	5	15.2	8.35	11.6	3.33
B-10	5	40.9	38.0	39.4	1.31

+ MEDIAN VALUE

TABLE 7 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN	STANDARD DEVIATION
ZINC					
B-1	5	31.6	24.2	27.7	3.00
B-2	5	43.4	26.1	34.4	6.76
B-3	5	35.3	24.1	29.4	4.48
B-4	5	41.8	33.5	37.6	3.83
B-5	5	45.5	38.1	42.7	3.35
B-6	5	107	87	96.4	8.52
B-7	5	54.2	31.7	42.3	7.99
B-8	5	21.2	16.3	17.8	2.01
B-9	5	25.0	18.9	21.0	2.66
B-10	5	110	102	105	3.11

+ MEDIAN VALUE

TABLE 8

METALS IN SEDIMENTS COLLECTED IN DITCHES LEADING TO THE PUMP STATIONS

(μg/g dry wt)

METAL	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
Arsenic	8.68	3.02	6.16	2.08
Cadmium	1.45	0.22	0.84	0.54
Chromium	38.4	28.6	33.9	3.89
Copper	72.7	18.6	34.32	21.9
Iron	27100	20000	23540	3213
Lead	81.8	12.9	36.3	27.5
Magnesium	9300	7100	7860	868
Manganese	321	203	273	58.0
Mercury	0.069	0.016	0.040	0.020
Mo	4.3	1.1	2.4	1.26
Nickel	64.9	28.7	42.0	16.7
Zinc	173	62.6	115.2	52.2

NOTE: EACH SAMPLE FROM ABOVE EACH PUMP STATION WAS A COMPOSITE SAMPLE

	INDIVIDUAL ANALYSES				
METAL	P-1	P-2	P-3	P-4	P-5
ARSENIC	3.02	8.68	5.57	6.81	6.72
CADMIUM	0.32	1.45	0.22	1.05	1.17
CHROMIUM	28.6	31.8	34.0	38.4	36.7
COPPER	22.7	72.7	18.6	30.2	27.4
IRON	21700	26800	20000	27100	22100
LEAD	41.5	81.8	12.9	21.5	23.8
MAGNESIUM	7400	9300	7100	8000	7500
MANGANESE	321	305	218	203	320
MERCURY	0.016	0.069	0.030	0.042	0.043
MOLYBDENUM	1.1	2.6	1.4	2.6	4.3
NICKEL	29.4	54.8	28.7	32.3	64.9
ZINC	76.8	173	62.6	94.8	169

TABLE 9

METALS IN SEDIMENTS COLLECTED AT THE MOUTHS OF THE TRIBUTARIES

(µg/g dry wt)

METAL	R-1 Serpentine R.	R-2 Nicomekl R.	R-3 Campbell R.
Arsenic	8.00	4.33	7.65
Cadmium	0.42	0.34	0.29
Chromium	42.8	40.4	47.3
Copper	32.1	21.8	27.3
Iron	27 300	24 100	23 500
Lead	42.1	16.6	12.2
Magnesium	7 600	7 200	8 200
Manganese	304	341	492
Mercury	0.044	0.033	0.037
Molybdenum	1.5	<1.0	2.8
Nickel	39.2	34.1	36.3
Zinc	114	92.2	84.7

NOTE: EACH SAMPLE FROM ABOVE EACH PUMP STATION WAS A COMPOSITE SAMPLE

TABLE 10

SUMMARY OF CHLORINATED PHENOL AND PCB CONCENTRATIONS IN SOFT-SHELLED CLAMS FROM BOUNDARY BAY

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g wet wt)	MINIMUM (µg/g wet wt)	MEAN (µg/g wet wt)	STANDARD DEVIATION
TRICHLOROPHENOL					
SITE B-1	7	<0.0002	<0.0002	<0.0002	-
SITE B-5	5	<0.0002	<0.0002	<0.0002	-
TETRACHLOROPHENOL					
SITE B-1	7	0.003	<0.0002	0.0008	0.0003
SITE B-5	5	0.0008	<0.0002	<0.0002+	-
PENTACHLOROPHENOL					
SITE B-1	7	0.002	<0.0002	0.0010	0.0005
SITE B-5	5	0.001	0.0006	0.0009	0.0002
PCBs					
SITE B-1	7	0.015	<0.001	0.006	0.005
SITE B-5	5	<0.001	<0.001	<0.001	-

TABLE 11

SUMMARY OF CHLORINATED PHENOL AND PCB CONCENTRATIONS IN CRABS (C. MAGISTER) FROM BOUNDARY BAY

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g wet wt)	MINIMUM (µg/g wet wt)	MEAN (µg/g wet wt)	STANDARD DEVIATION
TRICHLOROPHENOL					
SITE B-9	7F	<0.0002	<0.0002	<0.0002	-
	1HF	<0.0002	-	-	-
SITE B-10	5M	0.010	<0.0002	<0.0002+	-
	4H	<0.0002	<0.0002	<0.0002	-
TETRACHLOROPHENOL					
SITE B-9	7F	0.0004	<0.0002	<0.0002+	-
	1HF	<0.0002	-	-	-
SITE B-10	5M	0.010	<0.0002	0.0027	0.0041
	4H	0.008	<0.0002	0.0022	0.0039
PENTACHLOROPHENOL					
SITE B-9	7F	0.0010	<0.0002	0.0005	0.0003
	1HF	0.002	-	-	-
SITE B-10	5M	0.0030	<0.0002	0.0012	0.0011
	4H	0.002	<0.0002	0.0008	0.0009
PCBs					
SITE B-9	7F	0.020	<0.001	<0.001+	-
	1HF	0.016	-	-	-
SITE B-10	5M	0.031	<0.001	<0.001 +	-
	4H	0.035	0.014	0.026	0.010

-1HF REFERS TO HEPATOPANCREAS FROM 4 FEMALE CRABS
-7F REFERS TO MUSCLE FROM 4 MALE AND 5 FEMALE (TWO COMPOSITES OF TWO) CRABS
-5M REFERS TO MUSCLE FROM 5 MALE CRABS
-4H REFERS TO MUSCLE FROM 4 COMPOSITE HEPATOPANCREAS SAMPLES, 2 FROM 3 MALES AND 4 MALES, AND TWO FROM A MIXTURE FROM 3 MALES AND 4 FEMALES AND 4 MALES AND 5 FEMALES

TABLE 12
SUMMARY OF CHLORINATED PHENOL AND PCB CONCENTRATIONS IN FISH FROM BOUNDARY BAY

CHARACTERISTIC (No. of Values)	MAXIMUM	MINIMUM (µg/g wet wt)	MEAN	STANDARD DEVIATION
TRICHLOROPHENOL				
B-9				
SHINER PERCH (6)	<0.0002	<0.0002	<0.0002	-
3-SPINE ST'BACK(3)	<0.0002	<0.0002	<0.0002	-
STAGH'N SC'PIN(4)	<0.0002	<0.0002	<0.0002	-
B-10				
SNAKE PR'BACK(5)	<0.0002	<0.0002	<0.0002	-
BUTTER SOLE(5)	<0.0002	<0.0002	<0.0002	-
PACIFIC SANDAB(4)	0.009	<0.0002	<0.0002+	-
STARRY FLOUNDER(5F)	<0.0002	<0.0002	<0.0002	-
(3L)	<0.0002	<0.0002	<0.0002	-
TETRACHLOROPHENOL				
B-9				
SHINER PERCH (6)	0.0004	<0.0002	<0.0002+	-
3-SPINE ST'BACK(3)	0.0006	<0.0002	0.0004	0.0002
STAGH'N SC'PIN(4)	0.0008	<0.0002	<0.0002+	-
B-10				
SNAKE PR'BACK(5)	0.0006	<0.0002	<0.0002+	-
BUTTER SOLE(5)	0.0030	<0.0002	0.0013	0.0012
PACIFIC SANDAB(4)	0.010	0.004	0.007	0.003
STARRY FLOUNDER(5F)	0.002	<0.0002	0.0009	0.0007
(3L)	0.003	<0.0002	0.0013	0.0015
PENTACHLOROPHENOL				
B-9				
SHINER PERCH (6)	0.001	<0.0002	<0.0002+	-
3-SPINE ST'BACK(3)	0.0005	<0.0002	<0.0002+	-
STAGH'N SC'PIN(4)	0.0008	<0.0002	0.0005	0.00025
B-10				
SNAKE PR'BACK(5)	0.0010	<0.0002	0.0006	0.0004
BUTTER SOLE(5)	0.0020	<0.0002	0.0016	0.0008
PACIFIC SANDAB(4)	0.007	0.002	0.004	0.002
STARRY FLOUNDER(5F)	0.001	0.0008	0.001	0.0001
(3L)	0.001	0.0006	0.0007	0.0002

TABLE 12

Continued

CHARACTERISTIC (No. of Values)	MAXIMUM	MINIMUM (µg/g wet wt)	MEAN	STANDARD DEVIATION
PCBs				
B-9				
SHINER PERCH (6)	0.061	0.014	0.038	0.020
3-SPINE ST'BACK(3)	0.025	0.010	0.016	0.007
STAGH'N SC'PIN(4)	0.042	0.009	0.020	0.015
B-10				
SNAKE PR'BACK(5)	0.026	0.017	0.021	0.003
BUTTER SOLE(5)	0.011	0.006	0.008	0.002
PACIFIC SANDAB(4)	0.019	<0.001	0.009	0.007
STARRY FLOUNDER(5F)	0.033	<0.001	0.013	0.113
(3L)	0.054	0.032	0.041	0.011

-STARRY FLOUNDER(5F) REPRESENTS 5 MUSCLE SAMPLES
-STARRY FLOUNDER(3L) REPRESENTS 3 LIVER SAMPLES

TABLE 13

SUMMARY OF CHLORINATED PHENOL AND PCB CONCENTRATIONS IN BOUNDARY BAY SEDIMENTS

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN (µg/g dry wt)	STANDARD DEVIATION
TRICHLOROPHENOL					
B-1	5	<0.005	<0.005	<0.005	-
B-2	5	<0.005	<0.005	<0.005	-
B-3	5	<0.005	<0.005	<0.005	-
B-4	5	<0.005	<0.005	<0.005	-
B-5	5	<0.005	<0.005	<0.005	-
B-6	5	<0.005	<0.005	<0.005	-
B-7	5	<0.005	<0.005	<0.005	-
B-8	5	<0.005	<0.005	<0.005	-
B-9	5	<0.005	<0.005	<0.005	-
B-10	5	<0.005	<0.005	<0.005	-
TETRACHLOROPHENOL					
B-1	5	<0.005	<0.005	<0.005	-
B-2	5	<0.005	<0.005	<0.005	-
B-3	5	<0.005	<0.005	<0.005	-
B-4	5	<0.005	<0.005	<0.005	-
B-5	5	<0.005	<0.005	<0.005	-
B-6	5	<0.005	<0.005	<0.005	-
B-7	5	<0.005	<0.005	<0.005	-
B-8	5	<0.005	<0.005	<0.005	-
B-9	5	<0.005	<0.005	<0.005	-
B-10	5	<0.005	<0.005	<0.005	-
PENTACHLOROPHENOL					
B-1	5	<0.005	<0.005	<0.005	-
B-2	5	<0.005	<0.005	<0.005	-
B-3	5	<0.005	<0.005	<0.005	-
B-4	5	<0.005	<0.005	<0.005	-
B-5	5	<0.005	<0.005	<0.005	-
B-6	5	<0.005	<0.005	<0.005	-
B-7	5	<0.005	<0.005	<0.005	-
B-8	5	<0.005	<0.005	<0.005	-
B-9	5	<0.005	<0.005	<0.005	-
B-10	5	<0.005	<0.005	<0.005	-

TABLE 13 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN (µg/g dry wt)	STANDARD DEVIATION
PCBs					
B-1	5	<0.010	<0.010	<0.010	-
B-2	5	<0.010	<0.010	<0.010	-
B-3	5	<0.010	<0.010	<0.010	-
B-4	5	<0.010	<0.010	<0.010	-
B-5	5	<0.010	<0.010	<0.010	-
B-6	5	<0.010	<0.010	<0.010	-
B-7	5	<0.010	<0.010	<0.010	-
B-8	5	<0.010	<0.010	<0.010	-
B-9	5	<0.010	<0.010	<0.010	-
B-10	5	0.017	<0.010	<0.010+	-

+ MEDIAN VALUE

TABLE 14

SUMMARY OF CHLORINATED PHENOL AND PCB CONCENTRATIONS IN SEDIMENTS FROM DITCHES LEADING TO THE FIVE PUMP STATIONS

CHARACTERISTIC	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STANDARD DEVIATION
Trichlorophenol	<0.005	<0.005	<0.005	-
Tetrachlorophenol	<0.005	<0.005	<0.005	-
Pentachlorophenol	0.005	<0.005	<0.005	-
PCBs	0.034	<0.010	<0.010+	-

+ MEDIAN VALUE

TABLE 15

SUMMARY OF CHLORINATED PHENOL AND PCB CONCENTRATIONS IN BOUNDARY BAY TRIBUTARIES

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
		(µg/g dry wt)		
Trichlorophenol	<0.005	<0.005	<0.005	-
Tetrachlorophenol	<0.005	<0.005	<0.005	-
Pentachlorophenol	0.005	<0.005	<0.005	-
PCBs	0.024	<0.010	<0.010+	-

+ MEDIAN VALUE

TABLE 16
SUMMARY OF PHTHALATE ESTER CONCENTRATIONS IN SOFT-SHELLED CLAMS FROM BOUNDARY BAY

PHTHALATE	NO. OF VALUES	MAXIMUM	MINIMUM (µg/g wet wt)	MEAN	STD DEV
DIMETHYL					
SITE B-1	7	0.04	<0.01	<0.01+	-
SITE B-5	5	0.1	<0.01	<0.01+	-
DIETHYL					
SITE B-1	7	0.03	<0.01	<0.01+	-
SITE B-5	5	<0.01	<0.01	<0.01	-
DI-N-BUTYL					
SITE B-1	7	0.28	0.056	0.14	0.10
SITE B-5	5	0.20	0.03	0.11	0.06
BUTYL BENZYL					
SITE B-1	7	0.16	<0.01	<0.01+	-
SITE B-5	5	0.11	<0.01	<0.01+	-
DI-N-OCTYL					
SITE B-1	7	<0.01	<0.01	<0.01	-
SITE B-5	5	<0.01	<0.01	<0.01	-
BIS(2-ETHYLHEXYL)					
SITE B-1	7	0.23	0.061	0.128	0.059
SITE B-5	5	0.3	<0.01	0.11	0.12
LIPIDS					
SITE B-1	7	1.87	1.23	1.55	0.24
SITE B-5	5	0.87	0.65	0.73	0.09
MOISTURE					
SITE B-1	7	85.6	75.8	81.3	3.41
SITE B-5	5	89.5	85.5	87.3	1.58

+ MEDIAN VALUE

TABLE 17
SUMMARY OF PHTHALATE ESTER CONCENTRATIONS IN CRABS (C. MAGISTER) FROM BOUNDARY BAY

PHTHALATE	NO. OF VALUES	MAXIMUM	MINIMUM (µg/g wet wt)	MEAN	STD DEV
DIMETHYL					
SITE B-9	7F	0.085	<0.01	<0.01+	-
	1HF	<0.01	-	-	-
SITE B-10	5M	<0.01	<0.01	<0.01	-
	4H	<0.01	<0.01	<0.01	-
DIETHYL					
SITE B-9	7F	0.064	<0.01	<0.01+	-
	1HF	0.05	-	-	-
SITE B-10	5M	<0.01	<0.01	<0.01	-
	4H	0.055	<0.01	<0.01+	-
DI-N-BUTYL					
SITE B-9	7F	0.42	<0.01	0.128	0.134
	1HF	0.21	-	-	-
SITE B-10	5M	0.083	<0.01	<0.01+	-
	4H	0.23	0.096	0.18 0	0.061
BUTYL BENZYL					
SITE B-9	7F	0.12	<0.01	<0.01+	-
	1HF	0.11	-	-	-
SITE B-10	5M	0.14	<0.01	0.06	0.048
	4H	0.16	0.05	0.11	0.048
DI-N-OCTYL					
SITE B-9	7F	<0.01	<0.01	<0.01	-
	1HF	0.12	-	-	-
SITE B-10	5M	0.21	<0.01	<0.01+	-
	4H	0.11	<0.01	0.044	0.047
BIS(2-ETHYLHEXYL)					
SITE B-9	7F	0.13	<0.01	0.069	0.055
	1HF	0.80	-	-	-
SITE B-10	5M	0.68	<0.01	<0.01+	-
	4H	0.82	0.30	0.48	0.24

+ MEDIAN VALUE

TABLE 17
(Continued)

PHTHALATE	NO. OF VALUES	MAXIMUM	MINIMUM (µg/g wet wt)	MEAN	STD DEV
LIPIDS					
SITE B-9	7F	1.01	0.65	0.87	0.12
	1HF	4.72	-	-	-
SITE B-10	5M	1.06	0.71	0.88	0.14
	4H	6.19	1.37	3.68	1.98
MOISTURE					
SITE B-9	7F	88.2	79.5	83.4	2.91
	1HF	85.5	-	-	-
SITE B-10	5M	87.8	75.8	79.5	4.91
	4H	90.3	81.3	85.6	3.82

-1HF REFERS TO HEPATOPANCREAS FROM 4 FEMALE CRABS
-7F REFERS TO MUSCLE FROM 4 MALE AND 5 FEMALE (TWO COMPOSITES OF TWO) CRABS
-5M REFERS TO MUSCLE FROM 5 MALE CRABS
-4H REFERS TO FLESH FROM 4 COMPOSITE HEPATOPANCREAS SAMPLES, 2 FROM 3 MALES AND 4 MALES, AND TWO FROM A MIXTURE FROM 3 MALES AND 4 FEMALES AND 4 MALES AND 5 FEMALES

TABLE 18
SUMMARY OF PHTHALATE ESTER CONCENTRATIONS IN FISH FROM BOUNDARY BAY

CHARACTERISTIC (No. of Values)	MAXIMUM	MINIMUM (µg/g wet wt)	MEAN	STANDARD DEVIATION
DIMETHYL				
B-9				
SHINER PERCH (6)	<0.01	<0.01	<0.01	-
3-SPINE ST'BACK(3)	<0.01	<0.01	<0.01	-
STAGH'N SC'PIN(4)	<0.01	<0.01	<0.01	-
B-10				
SNAKE PR'BACK(5)	<0.01	<0.01	<0.01	-
BUTTER SOLE(5)	<0.01	<0.01	<0.01	-
PACIFIC SANDAB(4)	<0.01	<0.01	<0.01	-
STARRY FLOUNDER(5F)	<0.01	<0.01	<0.01	-
(3L)	<0.01	<0.01	<0.01	-
DIETHYL				
B-9				
SHINER PERCH (6)	<0.01	<0.01	<0.01	-
3-SPINE ST'BACK(3)	<0.01	<0.01	<0.01	-
STAGH'N SC'PIN(4)	0.16	<0.01	<0.01+	-
B-10				
SNAKE PR'BACK(5)	<0.01	<0.01	<0.01	-
BUTTER SOLE(5)	<0.01	<0.01	<0.01	-
PACIFIC SANDAB(4)	<0.01	<0.01	<0.01	-
STARRY FLOUNDER(5F)	<0.01	<0.01	<0.01	-
(3L)	<0.01	<0.01	<0.01	-
DI-N-BUTYL				
B-9				
SHINER PERCH (6)	0.084	<0.01	0.054	0.034
3-SPINE ST'BACK(3)	0.058	<0.01	<0.01+	-
STAGH'N SC'PIN(4)	<0.01	<0.01	<0.01	-
B-10				
SNAKE PR'BACK(5)	0.14	<0.01	0.068	0.026
BUTTER SOLE(5)	0.15	<0.01	0.092	0.056
PACIFIC SANDAB(4)	0.13	<0.01	<0.01+	-
STARRY FLOUNDER(5F)	0.07	<0.01	<0.01+	-
(3L)	0.31	0.11	0.20	0.10

+ MEDIAN VALUE

TABLE 18

Continued

CHARACTERISTIC (No. of Values)	MAXIMUM	MINIMUM (µg/g wet wt)	MEAN	STANDARD DEVIATION
BUTYL BENZYL				
B-9				
SHINER PERCH (6)	0.052	<0.01	<0.01+	-
3-SPINE ST'BACK(3)	0.059	<0.01	<0.01+	-
STAGH'N SC'PIN(4)	0.52	<0.01	<0.01	-
B-10				
SNAKE PR'BACK(5)	0.072	0.050	0.055	0.010
BUTTER SOLE(5)	1.47	<0.01	0.50	0.647
PACIFIC SANDAB(4)	0.05	<0.01	<0.01	-
STARRY FLOUNDER(5F)	0.10	<0.01	<0.01	-
(3L)	0.83	<0.01	0.31	0.450
DI-N-OCTYL				
B-9				
SHINER PERCH (6)	<0.01	<0.01	<0.01	-
3-SPINE ST'BACK(3)	<0.01	<0.01	<0.01	-
STAGH'N SC'PIN(4)	<0.01	<0.01	<0.01	-
B-10				
SNAKE PR'BACK(5)	<0.01	<0.01	<0.01	-
BUTTER SOLE(5)	<0.01	<0.01	<0.01	-
PACIFIC SANDAB(4)	<0.01	<0.01	<0.01	-
STARRY FLOUNDER(5F)	<0.01	<0.01	<0.01	-
(3L)	0.054	<0.01	0.039	0.025
BIS(2-ETHYLHEXYL)				
B-9				
SHINER PERCH (6)	0.42	0.07	0.238	0.158
3-SPINE ST'BACK(3)	0.33	0.068	0.157	0.15
STAGH'N SC'PIN(4)	0.34	0.15	0.22	0.086
B-10				
SNAKE PR'BACK(5)	0.80	<0.01	0.27	0.32
BUTTER SOLE(5)	1.59	0.095	0.459	0.635
PACIFIC SANDAB(4)	0.20	<0.01	0.07	0.009
STARRY FLOUNDER(5F)	0.26	0.05	0.118	0.089
(3L)	0.56	0.29	0.46	0.15

-STARRY FLOUNDER(5F) REPRESENTS 5 MUSCLE SAMPLES
-STARRY FLOUNDER(3L) REPRESENTS 3 LIVER SAMPLES
+ MEDIAN VALUE

TABLE 19

SUMMARY OF PHTHALATE ESTER CONCENTRATIONS IN BOUNDARY BAY SEDIMENTS

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN (µg/g dry wt)	STANDARD DEVIATION
DIMETHYL PHTHALATE					
B-1	5	<0.10	<0.10	<0.10	-
B-2	5	<0.10	<0.10	<0.10	-
B-3	5	<0.10	<0.10	<0.10	-
B-4	5	<0.10	<0.10	<0.10	-
B-5	5	<0.10	<0.10	<0.10	-
B-6	5	<0.10	<0.10	<0.10	-
B-7	5	<0.10	<0.10	<0.10	-
B-8	5	<0.10	<0.10	<0.10	-
B-9	5	<0.10	<0.10	<0.10	-
B-10	5	<0.10	<0.10	<0.10	-
DIETHYL PHTHALATE					
B-1	5	<0.10	<0.10	<0.10	-
B-2	5	<0.10	<0.10	<0.10	-
B-3	5	<0.10	<0.10	<0.10	-
B-4	5	<0.10	<0.10	<0.10	-
B-5	5	<0.10	<0.10	<0.10	-
B-6	5	0.15	<0.10	<0.10+	-
B-7	5	<0.10	<0.10	<0.10	-
B-8	5	<0.10	<0.10	<0.10	-
B-9	5	<0.10	<0.10	<0.10	-
B-10	5	<0.10	<0.10	<0.10	-
DI-N-BUTYL PHTHALATE					
B-1	5	<0.10	<0.10	<0.10	-
B-2	5	<0.10	<0.10	<0.10	-
B-3	5	<0.10	<0.10	<0.10	-
B-4	5	0.15	<0.10	<0.10+	-
B-5	5	0.12	<0.10	<0.10+	-
B-6	5	0.26	<0.10	<0.10+	-
B-7	5	0.18	<0.10	<0.10+	-
B-8	5	0.10	<0.10	<0.10+	-
B-9	5	0.22	<0.10	<0.10+	-
B-10	5	0.16	<0.10	<0.10+	-

+ MEDIAN VALUE

TABLE 19 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN	STANDARD DEVIATION
BUTYL BENZYL PHTHALATE					
B-1	5	<0.10	<0.10	<0.10	-
B-2	5	<0.10	<0.10	<0.10	-
B-3	5	<0.10	<0.10	<0.10	-
B-4	5	<0.10	<0.10	<0.10	-
B-5	5	<0.10	<0.10	<0.10	-
B-6	5	<0.10	<0.10	<0.10	-
B-7	5	<0.10	<0.10	<0.10	-
B-8	5	<0.10	<0.10	<0.10	-
B-9	5	0.16	<0.10	<0.10+	-
B-10	5	<0.10	<0.10	<0.10	-
DI-N-OCTYL PHTHALATE					
B-1	5	<0.10	<0.10	<0.10	-
B-2	5	<0.10	<0.10	<0.10	-
B-3	5	<0.10	<0.10	<0.10	-
B-4	5	<0.10	<0.10	<0.10	-
B-5	5	<0.10	<0.10	<0.10	-
B-6	5	<0.10	<0.10	<0.10	-
B-7	5	0.31	<0.10	<0.10+	-
B-8	5	<0.10	<0.10	<0.10	-
B-9	5	0.15	<0.10	<0.10+	-
B-10	5	<0.10	<0.10	<0.10	-
BIS(2-ETHYLHEXYL) PHTHALATE					
B-1	5	0.150	<0.10	<0.10+	-
B-2	5	0.16	<0.10	<0.10+	-
B-3	5	0.36	<0.10	<0.10+	-
B-4	5	0.13	<0.10	<0.10+	-
B-5	5	0.24	<0.10	<0.10+	-
B-6	5	0.33	<0.10	<0.10+	-
B-7	5	1.08	0.40	0.66	0.256
B-8	5	0.60	0.51	0.54	0.037
B-9	5	0.60	0.46	0.52	0.058
B-10	5	1.48	0.68	1.05	0.137

+ MEDIAN VALUE

TABLE 20

SUMMARY OF PHTHALATE ESTER CONCENTRATIONS IN SEDIMENTS FROM DITCHES LEADING TO THE FIVE PUMP STATIONS

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
		(µg/g dry wt)		
Dimethyl	<0.10	<0.10	<0.10	-
Diethyl	<0.10	<0.10	<0.10	-
Di-n-butyl	0.19	<0.10	<0.10+	-
Butyl Benzyl	<0.10	<0.10	<0.10	-
Di-n-Octyl	<0.10	<0.10	<0.10	-
Bis(2-Ethylhexyl)	1.34	<0.10	0.484	0.535

+ MEDIAN VALUE

INDIVIDUAL ANALYSES

Phthalate	P-1	P-2	P-3	P-4	P-5
Dimethyl	<0.10	<0.10	<0.10	<0.10	<0.10
Diethyl	<0.10	<0.10	<0.10	<0.10	<0.10
Di-n-butyl	<0.10	0.24	<0.10	<0.10	<0.10
Butyl Benzyl	<0.10	<0.10	<0.10	<0.10	<0.10
Di-n-Octyl	<0.10	<0.10	<0.10	<0.10	<0.10
Bis(2-Ethylhexyl)	0.12	1.34	<0.10	0.68	0.18

TABLE 21

SUMMARY OF PHTHALATE ESTER CONCENTRATIONS IN SEDIMENTS FROM BOUNDARY BAY TRIBUTARIES

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
		(µg/g dry wt)		
Dimethyl	<0.10	<0.10	<0.10	-
Diethyl	<0.10	<0.10	<0.10	-
Di-n-butyl	0.17	<0.10	<0.10+	-
Butyl Benzyl	<0.10	<0.10	<0.10	-
Di-n-Octyl	<0.10	<0.10	<0.10	-
Bis(2-Ethylhexyl)	0.56	0.33	0.46	0.118

+ MEDIAN VALUE
ONE SAMPLE WAS COLLECTED FROM NEAR THE MOUTHS OF THE SERPENTINE, NICOMEKL, AND LITTLE CAMPBELL RIVERS.

INDIVIDUAL RESULTS

PHTHALATE	R-1	R-2	R-3
Dimethyl	<0.10	<0.10	<0.10
Diethyl	<0.10	<0.10	<0.10
Di-n-butyl	<0.10	<0.10	0.17
Butyl Benzyl	<0.10	<0.10	<0.10
Di-n-Octyl	<0.10	<0.10	<0.10
Bis(2-Ethylhexyl)	0.49	0.33	0.56

TABLE 22

SUMMARY OF PAH CONCENTRATIONS IN SOFT-SHELLED CLAMS FROM BOUNDARY BAY

(µg/g wet wt)

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN
ACENAPHTHENE			
SITE B-1	<0.004	<0.004	<0.004
SITE B-5	<0.004	<0.004	<0.004
ACENAPHTHYLENE			
SITE B-1	<0.004	<0.004	<0.004
SITE B-5	<0.004	<0.004	<0.004
ANTHRACENE			
SITE B-1	<0.004	<0.004	<0.004
SITE B-5	<0.004	<0.004	<0.004
BENZO(A)ANTHRACENE			
SITE B-1	<0.01	<0.01	<0.01
SITE B-5	<0.01	<0.01	<0.01
BENZO(A)PYRENE			
SITE B-1	<0.02	<0.02	<0.02
SITE B-5	<0.02	<0.02	<0.02
BENZO(B)FLUORANTHENE			
SITE B-1	<0.02	<0.02	<0.02
SITE B-5	<0.02	<0.02	<0.02
BENZO(GHI)PERYLENE			
SITE B-1	<0.02	<0.02	<0.02
SITE B-5	<0.02	<0.02	<0.02
BENZO(K) FLUORANTHENE			
SITE B-1	<0.02	<0.02	<0.02
SITE B-5	<0.02	<0.02	<0.02
CHRYSENE			
SITE B-1	<0.01	<0.01	<0.01
SITE B-5	<0.01	<0.01	<0.01

TABLE 22 (Continued)

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN
		(µg/g wet wt)	
DIBENZO (A,H) ANTHRACENE			
SITE B-1	<0.02	<0.02	<0.02
SITE B-5	<0.02	<0.02	<0.02
FLUORANTHENE			
SITE B-1	<0.01	<0.01	<0.01
SITE B-5	<0.01	<0.01	<0.01
FLUORENE			
SITE B-1	<0.004	<0.004	<0.004
SITE B-5	<0.004	<0.004	<0.004
INDENO (1,2,3-C,D) PYRENE			
SITE B-1	<0.02	<0.02	<0.02
SITE B-5	<0.02	<0.02	<0.02
NAPHTHALENE			
SITE B-1	<0.004	<0.004	<0.004
SITE B-5	<0.004	<0.004	<0.004
PHENANTHRENE			
SITE B-1	<0.004	<0.004	<0.004
SITE B-5	<0.004	<0.004	<0.004
PYRENE			
SITE B-1	<0.01	<0.01	<0.01
SITE B-5	<0.01	<0.01	<0.01
NUMBER OF SAMPLES:	7 AT SITE B-1 5 AT SITE B-5		

TABLE 23

SUMMARY OF PAH CONCENTRATIONS IN CRABS (C. MAGISTER) FROM BOUNDARY BAY

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN
		(µg/g wet wt)	
ACENAPHTHENE			
SITE B-9	<0.004	<0.004	<0.004
SITE B-10	<0.004	<0.004	<0.004
ACENAPHTHYLENE			
SITE B-9	<0.004	<0.004	<0.004
SITE B-10	<0.004	<0.004	<0.004
ANTHRACENE			
SITE B-9	<0.004	<0.004	<0.004
SITE B-10	<0.004	<0.004	<0.004
BENZO(A) ANTHRACENE			
SITE B-9	<0.01	<0.01	<0.01
SITE B-10	<0.01	<0.01	<0.01
BENZO(A)PYRENE			
SITE B-9	<0.02	<0.02	<0.02
SITE B-10	<0.02	<0.02	<0.02
BENZO(B)FLUORANTHENE			
SITE B-9	<0.02	<0.02	<0.02
SITE B-10	<0.02	<0.02	<0.02
BENZO(G,H,I)PERYLENE			
SITE B-9	<0.02	<0.02	<0.02
SITE B-10	<0.02	<0.02	<0.02
BENZO(K)FLUORANTHENE			
SITE B-9	<0.02	<0.02	<0.02
SITE B-10	<0.02	<0.02	<0.02

TABLE 23 (Continued)

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN
		(µg/g wet wt)	
CHRYSENE			
SITE B-9	<0.01	<0.01	<0.01
SITE B-10	<0.01	<0.01	<0.01
DIBENZO (A,H) ANTHRACENE			
SITE B-9	<0.02	<0.02	<0.02
SITE B-10	<0.02	<0.02	<0.02
FLUORANTHENE			
SITE B-9	<0.01	<0.01	<0.01
SITE B-10	<0.01	<0.01	<0.01
FLUORENE			
SITE B-9	<0.004	<0.004	<0.004
SITE B-10	<0.004	<0.004	<0.004
INDENO (1,2,3-C,D) PYRENE			
SITE B-9	<0.02	<0.02	<0.02
SITE B-10	<0.02	<0.02	<0.02
NAPHTHALENE			
SITE B-9	<0.004	<0.004	<0.004
SITE B-10	<0.004	<0.004	<0.004
PHENANTHRENE			
SITE B-9	<0.004	<0.004	<0.004
SITE B-10	<0.004	<0.004	<0.004
PYRENE			
SITE B-9	<0.01	<0.01	<0.01
SITE B-10	<0.01	<0.01	<0.01

NUMBER OF SAMPLES: 1 HEPATOPANCREAS AND 7 MUSCLE SAMPLES AT SITE B-9
4 HEPATOPANCREAS AND 5 MUSCLE SAMPLES AT SITE B-10

TABLE 24

SUMMARY OF PAH CONCENTRATIONS IN BOUNDARY BAY FISH

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN
		(µg/g wet wt)	
ACENAPHTHENE			
B-9			
SHINER PERCH (6)	<0.004	<0.004	<0.004
3-SPINE ST'BACK(3)	<0.004	<0.004	<0.004
STAGH'N SC'PIN(4)	<0.004	<0.004	<0.004
B-10			
SNAKE PR'BACK(5)	<0.004	<0.004	<0.004
BUTTER SOLE(5)	<0.004	<0.004	<0.004
PACIFIC SANDAB(4)	<0.004	<0.004	<0.004
STARRY FLOUNDER(5F)	<0.004	<0.004	<0.004
(3L)	<0.004	<0.004	<0.004
ACENAPHTHYLENE			
B-9			
SHINER PERCH (6)	<0.004	<0.004	<0.004
3-SPINE ST'BACK(3)	<0.004	<0.004	<0.004
STAGH'N SC'PIN(4)	<0.004	<0.004	<0.004
B-10			
SNAKE PR'BACK(5)	<0.004	<0.004	<0.004
BUTTER SOLE(5)	<0.004	<0.004	<0.004
PACIFIC SANDAB(4)	<0.004	<0.004	<0.004
STARRY FLOUNDER(5F)	<0.004	<0.004	<0.004
(3L)	<0.004	<0.004	<0.004
ANTHRACENE			
B-9			
SHINER PERCH (6)	<0.004	<0.004	<0.004
3-SPINE ST'BACK(3)	<0.004	<0.004	<0.004
STAGH'N SC'PIN(4)	<0.004	<0.004	<0.004
B-10			
SNAKE PR'BACK(5)	<0.004	<0.004	<0.004
BUTTER SOLE(5)	<0.004	<0.004	<0.004
PACIFIC SANDAB(4)	<0.004	<0.004	<0.004
STARRY FLOUNDER(5F)	<0.004	<0.004	<0.004
(3L)	<0.004	<0.004	<0.004

TABLE 24 (Continued)

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN
		(µg/g wet wt)	
BENZO(A)ANTHRACENE			
B-9			
SHINER PERCH (6)	<0.01	<0.01	<0.01
3-SPINE ST'BACK(3)	<0.01	<0.01	<0.01
STAGH'N SC'PIN(4)	<0.01	<0.01	<0.01
B-10			
SNAKE PR'BACK(5)	<0.01	<0.01	<0.01
BUTTER SOLE(5)	<0.01	<0.01	<0.01
PACIFIC SANDAB(4)	<0.01	<0.01	<0.01
STARRY FLOUNDER(5F)	<0.01	<0.01	<0.01
(3L)	<0.01	<0.01	<0.01
BENZO(A)PYRENE			
B-9			
SHINER PERCH (6)	<0.02	<0.02	<0.02
3-SPINE ST'BACK(3)	<0.02	<0.02	<0.02
STAGH'N SC'PIN(4)	<0.02	<0.02	<0.02
B-10			
SNAKE PR'BACK(5)	<0.02	<0.02	<0.02
BUTTER SOLE(5)	<0.02	<0.02	<0.02
PACIFIC SANDAB(4)	<0.02	<0.02	<0.02
STARRY FLOUNDER(5F)	<0.02	<0.02	<0.02
(3L)	<0.02	<0.02	<0.02
BENZO(B)FLUORANTHENE			
B-9			
SHINER PERCH (6)	<0.02	<0.02	<0.02
3-SPINE ST'BACK(3)	<0.02	<0.02	<0.02
STAGH'N SC'PIN(4)	<0.02	<0.02	<0.02
B-10			
SNAKE PR'BACK(5)	<0.02	<0.02	<0.02
BUTTER SOLE(5)	<0.02	<0.02	<0.02
PACIFIC SANDAB(4)	<0.02	<0.02	<0.02
STARRY FLOUNDER(5F)	<0.02	<0.02	<0.02
(3L)	<0.02	<0.02	<0.02

TABLE 24 (Continued)

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN
		(µg/g wet wt)	
BENZO(G,H,I)PERYLENE			
B-9			
SHINER PERCH (6)	<0.02	<0.02	<0.02
3-SPINE ST'BACK(3)	<0.02	<0.02	<0.02
STAGH'N SC'PIN(4)	<0.02	<0.02	<0.02
B-10			
SNAKE PR'BACK(5)	<0.02	<0.02	<0.02
BUTTER SOLE(5)	<0.02	<0.02	<0.02
PACIFIC SANDAB(4)	<0.02	<0.02	<0.02
STARRY FLOUNDER(5F)	<0.02	<0.02	<0.02
(3L)	<0.02	<0.02	<0.02
BENZO(K)FLUORANTHENE			
B-9			
SHINER PERCH (6)	<0.02	<0.02	<0.02
3-SPINE ST'BACK(3)	<0.02	<0.02	<0.02
STAGH'N SC'PIN(4)	<0.02	<0.02	<0.02
B-10			
SNAKE PR'BACK(5)	<0.02	<0.02	<0.02
BUTTER SOLE(5)	<0.02	<0.02	<0.02
PACIFIC SANDAB(4)	<0.02	<0.02	<0.02
STARRY FLOUNDER(5F)	<0.02	<0.02	<0.02
(3L)	<0.02	<0.02	<0.02
CHRYSENE			
B-9			
SHINER PERCH (6)	<0.01	<0.01	<0.01
3-SPINE ST'BACK(3)	<0.01	<0.01	<0.01
STAGH'N SC'PIN(4)	<0.01	<0.01	<0.01
B-10			
SNAKE PR'BACK(5)	<0.01	<0.01	<0.01
BUTTER SOLE(5)	<0.01	<0.01	<0.01
PACIFIC SANDAB(4)	<0.01	<0.01	<0.01
STARRY FLOUNDER(5F)	<0.01	<0.01	<0.01
(3L)	<0.01	<0.01	<0.01

TABLE 24 (Continued)

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN
		(µg/g wet wt)	
DIBENZO (A,H) ANTHRACENE			
B-9			
SHINER PERCH (6)	<0.02	<0.02	<0.02
3-SPINE ST'BACK(3)	<0.02	<0.02	<0.02
STAGH'N SC'PIN(4)	<0.02	<0.02	<0.02
B-10			
SNAKE PR'BACK(5)	<0.02	<0.02	<0.02
BUTTER SOLE(5)	<0.02	<0.02	<0.02
PACIFIC SANDAB(4)	<0.02	<0.02	<0.02
STARRY FLOUNDER(5F)	<0.02	<0.02	<0.02
(3L)	<0.02	<0.02	<0.02
FLUORANTHENE			
B-9			
SHINER PERCH (6)	<0.01	<0.01	<0.01
3-SPINE ST'BACK(3)	<0.01	<0.01	<0.01
STAGH'N SC'PIN(4)	<0.01	<0.01	<0.01
B-10			
SNAKE PR'BACK(5)	<0.01	<0.01	<0.01
BUTTER SOLE(5)	<0.01	<0.01	<0.01
PACIFIC SANDAB(4)	<0.01	<0.01	<0.01
STARRY FLOUNDER(5F)	<0.01	<0.01	<0.01
(3L)	<0.01	<0.01	<0.01
FLUORENE			
B-9			
SHINER PERCH (6)	<0.004	<0.004	<0.004
3-SPINE ST'BACK(3)	<0.004	<0.004	<0.004
STAGH'N SC'PIN(4)	<0.004	<0.004	<0.004
B-10			
SNAKE PR'BACK(5)	<0.004	<0.004	<0.004
BUTTER SOLE(5)	<0.004	<0.004	<0.004
PACIFIC SANDAB(4)	<0.004	<0.004	<0.004
STARRY FLOUNDER(5F)	<0.004	<0.004	<0.004
(3L)	<0.004	<0.004	<0.004

TABLE 24 (Continued)

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN
		(µg/g wet wt)	
INDENO (1,2,3-C,D) PYRENE			
B-9			
SHINER PERCH (6)	<0.02	<0.02	<0.02
3-SPINE ST'BACK(3)	<0.02	<0.02	<0.02
STAGH'N SC'PIN(4)	<0.02	<0.02	<0.02
B-10			
SNAKE PR'BACK(5)	<0.02	<0.02	<0.02
BUTTER SOLE(5)	<0.02	<0.02	<0.02
PACIFIC SANDAB(4)	<0.02	<0.02	<0.02
STARRY FLOUNDER(5F)	<0.02	<0.02	<0.02
(3L)	<0.02	<0.02	<0.02
NAPHTHALENE			
B-9			
SHINER PERCH (6)	<0.004	<0.004	<0.004
3-SPINE ST'BACK(3)	<0.004	<0.004	<0.004
STAGH'N SC'PIN(4)	<0.004	<0.004	<0.004
B-10			
SNAKE PR'BACK(5)	<0.004	<0.004	<0.004
BUTTER SOLE(5)	<0.004	<0.004	<0.004
PACIFIC SANDAB(4)	<0.004	<0.004	<0.004
STARRY FLOUNDER(5F)	<0.004	<0.004	<0.004
(3L)	<0.004	<0.004	<0.004
PHENANTHRENE			
B-9			
SHINER PERCH (6)	<0.004	<0.004	<0.004
3-SPINE ST'BACK(3)	<0.004	<0.004	<0.004
STAGH'N SC'PIN(4)	<0.004	<0.004	<0.004
B-10			
SNAKE PR'BACK(5)	<0.004	<0.004	<0.004
BUTTER SOLE(5)	<0.004	<0.004	<0.004
PACIFIC SANDAB(4)	<0.004	<0.004	<0.004
STARRY FLOUNDER(5F)	<0.004	<0.004	<0.004
(3L)	<0.004	<0.004	<0.004

TABLE 24 (Continued)

CHARACTERISTIC	MAXIMUM (µg/g wet wt)	MINIMUM	MEAN
PYRENE			
B-9			
SHINER PERCH (6)	<0.01	<0.01	<0.01
3-SPINE ST'BACK(3)	<0.01	<0.01	<0.01
STAGH'N SC'PIN(4)	<0.01	<0.01	<0.01
B-10			
SNAKE PR'BACK(5)	<0.01	<0.01	<0.01
BUTTER SOLE(5)	<0.01	<0.01	<0.01
PACIFIC SANDAB(4)	<0.01	<0.01	<0.01
STARRY FLOUNDER(5F)	<0.01	<0.01	<0.01
(3L)	<0.01	<0.01	<0.01

STARRY FLOUNDER(5F) REPRESENTS 5 MUSCLE SAMPLES
STARRY FLOUNDER(3L) REPRESENTS 3 LIVER SAMPLES

TABLE 25
SUMMARY OF PAH CONCENTRATIONS IN BOUNDARY BAY SEDIMENTS

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN (µg/g dry wt)	STANDARD DEVIATION
ACENAPHTHENE					
B-1	5	0.017	<0.005	<0.005+	-
B-2	5	0.070	<0.005	<0.005+	-
B-3	5	0.017	<0.005	<0.005+	-
B-4	5	<0.005	<0.005	<0.005	-
B-5	5	<0.005	<0.005	<0.005	-
B-6	5	<0.005	<0.005	<0.005	-
B-7	5	0.023	<0.005	<0.005+	-
B-8	5	<0.005	<0.005	<0.005	-
B-9	5	<0.005	<0.005	<0.005	-
B-10	5	0.081	<0.005	<0.005+	-
ACENAPHTHYLENE					
B-1	5	<0.005	<0.005	<0.005	-
B-2	5	0.043	<0.005	0.013	0.204
B-3	5	0.062	<0.005	<0.005+	-
B-4	5	<0.005	<0.005	<0.005	-
B-5	5	0.042	<0.005	<0.005+	-
B-6	5	<0.005	<0.005	<0.005	-
B-7	5	<0.005	<0.005	<0.005	-
B-8	5	<0.005	<0.005	<0.005	-
B-9	5	<0.005	<0.005	<0.005	-
B-10	5	0.021	<0.005	<0.005+	-
ANTHRACENE					
B-1	5	0.020	<0.005	<0.005+	-
B-2	5	0.071	<0.005	<0.005+	-
B-3	5	0.097	<0.005	<0.005+	-
B-4	5	0.015	<0.005	0.010	-
B-5	5	0.042	0.018	0.030	0.010
B-6	5	0.058	<0.005	0.036	0.018
B-7	5	0.051	<0.005	<0.005+	-
B-8	5	<0.005	<0.005	<0.005	-
B-9	5	<0.005	<0.005	<0.005	-
B-10	5	<0.005	<0.005	<0.005	-

+ MEDIAN VALUE

TABLE 25 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN (µg/g dry wt)	STANDARD DEVIATION
BENZO(A) ANTHRACENE					
B-1	5	0.072	<0.010	<0.010+	-
B-2	5	0.044	<0.010	<0.010+	-
B-3	5	0.043	<0.010	<0.010+	-
B-4	5	<0.010	<0.010	<0.010	-
B-5	5	<0.010	<0.010	<0.010	-
B-6	5	0.045	<0.010	<0.010+	-
B-7	5	<0.010	<0.010	<0.010	-
B-8	5	<0.010	<0.010	<0.010	-
B-9	5	<0.010	<0.010	<0.010	-
B-10	5	0.051	<0.010	<0.010+	-
BENZO(A) PYRENE					
B-1	5	<0.02	<0.02	<0.02	-
B-2	5	<0.02	<0.02	<0.02	-
B-3	5	<0.02	<0.02	<0.02	-
B-4	5	<0.02	<0.02	<0.02	-
B-5	5	<0.02	<0.02	<0.02	-
B-6	5	<0.02	<0.02	<0.02	-
B-7	5	<0.02	<0.02	<0.02	-
B-8	5	<0.02	<0.02	<0.02	-
B-9	5	<0.02	<0.02	<0.02	-
B-10	5	<0.02	<0.02	<0.02	-
BENZO(B) FLUORANTHENE					
B-1	5	0.190	<0.02	<0.02+	-
B-2	5	0.069	0.027	0.050	0.018
B-3	5	0.120	<0.02	<0.02+	-
B-4	5	0.160	<0.02	<0.02	-
B-5	5	0.066	<0.02	<0.02	-
B-6	5	<0.02	<0.02	<0.02	-
B-7	5	<0.02	<0.02	<0.02	-
B-8	5	<0.02	<0.02	<0.02	-
B-9	5	<0.02	<0.02	<0.02	-
B-10	5	0.170	<0.02	0.096	0.051

+ MEDIAN VALUE

TABLE 25 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN (µg/g dry wt)	STANDARD DEVIATION
BENZO(G,H,I) PERYLENE					
B-1	5	0.032	<0.02	<0.02+	-
B-2	5	<0.02	<0.02	<0.02	-
B-3	5	0.059	<0.02	<0.02+	-
B-4	5	0.046	<0.02	<0.02+	-
B-5	5	0.083	<0.02	<0.02+	-
B-6	5	0.300	<0.02	<0.02+	-
B-7	5	0.650	<0.02	<0.02+	-
B-8	5	0.028	<0.02	<0.02+	-
B-9	5	<0.02	<0.02	<0.02	-
B-10	5	0.420	<0.02	<0.02+	-
BENZO(K) FLUORANTHENE					
B-1	5	<0.02	<0.02	<0.02	-
B-2	5	<0.02	<0.02	<0.02	-
B-3	5	<0.02	<0.02	<0.02	-
B-4	5	<0.02	<0.02	<0.02	-
B-5	5	<0.02	<0.02	<0.02	-
B-6	5	0.120	<0.02	<0.02+	-
B-7	5	0.095	<0.02	<0.02+	-
B-8	5	<0.02	<0.02	<0.02	-
B-9	5	<0.02	<0.02	<0.02	-
B-10	5	0.130	<0.02	0.079	-
CHRYSENE					
B-1	5	0.060	<0.010	<0.010+	-
B-2	5	<0.010	<0.010	<0.010	-
B-3	5	<0.010	<0.010	<0.010	-
B-4	5	0.054	<0.010	<0.010+	-
B-5	5	<0.010	<0.010	<0.010	-
B-6	5	0.074	<0.010	<0.010+	-
B-7	5	<0.010	<0.010	<0.010	-
B-8	5	<0.010	<0.010	<0.010	-
B-9	5	<0.010	<0.010	<0.010	-
B-10	5	0.015	<0.010	<0.010+	-

+ MEDIAN VALUE

TABLE 25 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM	MEAN	STANDARD DEVIATION
DIBENZO (A,H) ANTHRACENE					
B-1	5	<0.02	<0.02	<0.02	-
B-2	5	<0.02	<0.02	<0.02	-
B-3	5	<0.02	<0.02	<0.02	-
B-4	5	<0.02	<0.02	<0.02	-
B-5	5	<0.02	<0.02	<0.02	-
B-6	5	1.24	0.63	0.89	0.232
B-7	5	0.099	<0.02	<0.02+	-
B-8	5	0.200	<0.02	<0.02+	-
B-9	5	<0.02	<0.02	<0.02	-
B-10	5	0.160	<0.02	<0.02+	-
FLUORANTHENE					
B-1	5	0.050	<0.010	0.029	0.017
B-2	5	0.910	<0.010	<0.010+	-
B-3	5	0.200	<0.010	0.076	-
B-4	5	0.075	<0.010	<0.010+	-
B-5	5	0.560	<0.010	0.445	0.103
B-6	5	0.780	0.370	0.563	0.135
B-7	5	0.048	<0.010	0.039	0.012
B-8	5	0.052	<0.010	0.031	-
B-9	5	<0.010	<0.010	<0.010	-
B-10	5	0.400	<0.010	0.266	0.157
FLUORENE					
B-1	5	0.010	<0.005	<0.005+	-
B-2	5	0.062	<0.005	0.041	0.019
B-3	5	0.079	<0.005	0.038	-
B-4	5	0.014	<0.005	0.010	-
B-5	5	0.051	0.008	0.027	0.016
B-6	5	0.075	<0.005	0.046	0.026
B-7	5	0.056	<0.005	0.021	-
B-8	5	<0.005	<0.005	<0.005	-
B-9	5	<0.005	<0.005	<0.005	-
B-10	5	0.039	<0.005	0.014	-

+ MEDIAN VALUE

TABLE 25 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN (µg/g dry wt)	STANDARD DEVIATION
INDENO (1,2,3-C,D) PYRENE					
B-1	5	<0.020	<0.020	<0.020	-
B-2	5	<0.020	<0.020	<0.020	-
B-3	5	0.400	<0.020	<0.020+	-
B-4	5	0.044	<0.020	<0.020+	-
B-5	5	<0.020	<0.020	<0.020	-
B-6	5	<0.020	<0.020	<0.020	-
B-7	5	0.047	<0.020	<0.020+	-
B-8	5	<0.020	<0.020	<0.020	-
B-9	5	<0.020	<0.020	<0.020	-
B-10	5	0.240	<0.020	0.115	0.092
NAPHTHALENE					
B-1	5	0.021	<0.005	0.011	-
B-2	5	0.013	<0.005	0.008	-
B-3	5	<0.005	<0.005	<0.005	-
B-4	5	<0.005	<0.005	<0.005	-
B-5	5	<0.005	<0.005	<0.005	-
B-6	5	<0.005	<0.005	<0.005	-
B-7	5	<0.005	<0.005	<0.005	-
B-8	5	<0.005	<0.005	<0.005	-
B-9	5	<0.005	<0.005	<0.005	-
B-10	5	<0.005	<0.005	<0.005	-
PHENANTHRENE					
B-1	5	0.020	<0.005	<0.005+	-
B-2	5	0.062	<0.005	<0.005+	-
B-3	5	<0.005	<0.005	<0.005	-
B-4	5	0.026	<0.005	0.015	-
B-5	5	0.092	<0.005	0.049	-
B-6	5	0.082	<0.005	0.035	-
B-7	5	<0.005	<0.005	<0.005	-
B-8	5	<0.005	<0.005	<0.005	-
B-9	5	<0.005	<0.005	<0.005	-
B-10	5	0.055	<0.005	<0.005+	-

+ MEDIAN VALUE

TABLE 25 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN (µg/g dry wt)	STANDARD DEVIATION
PYRENE					
B-1	5	0.031	<0.010	<0.010+	-
B-2	5	<0.010	<0.010	<0.010	-
B-3	5	0.012	<0.010	<0.010+	-
B-4	5	0.014	<0.010	<0.010+	-
B-5	5	<0.010	<0.010	<0.010	-
B-6	5	<0.010	<0.010	<0.010	-
B-7	5	<0 010	<0.010	<0.010	-
B-8	5	<0.010	<0.010	<0.010	-
B-9	5	<0.010	<0.010	<0.010	-
B-10	5	0.300	<0.010	0.180	0.120

+ MEDIAN VALUE

TABLE 26

PAHS IN SEDIMENTS COLLECTED IN DITCHES LEADING TO THE FIVE PUMP STATIONS

CHARACTERISTIC	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STD DEV
Acenaphthene	0.13	<0.005	0.06	0.056
Acenaphthylene	0.046	<0.005	<0.005+	-
Anthracene	0.096	<0.005	0.037	0.039
Benzo(a)anthracene	0.19	<0.010	<0.010+	-
Benzo(a)pyrene	<0.02	<0.02	<0.02	-
Benzo(b)fluoranthene	<0.02	<0.02	<0.02	-
Benzo(g,h,i)perylene	<0.02	<0.02	<0.02	-
Benzo(k)fluoranthene	<0.02	<0.02	<0.02	-
Chrysene	0.38	<0.010	<0.010+	-
Dibenzo(a,h)anthracene	<0.02	<0.02	<0.02	-
Fluoranthene	0.49	<0.010	0.232	0.227
Fluorene	0.085	<0.005	0.051	0.034
Indeno(1,2,3,c-d)pyrene	0.42	<0.02	<0.02+	-
Naphthalene	0.16	<0.005	0.069	0.059
Phenanthrene	0.50	<0.005	0.167	0.213
Pyrene	1.16	<0.010	0.337	0.497

+ MEDIAN VALUE

INDIVIDUAL ANALYSES

CHARACTERISTIC	P-1	P-2	P-3	P-4	P-5
Acenapthene	<0.005	0.13	<0.005	0.058	0.10
Acenapthylene	<0.005	0.046	<0.005	<0.005	0.033
Anthracene	<0.005	0.057	0.020	<0.005	0.096
Benzo(a)anthracene	<0.010	<0.010	0.042	0.19	<0.01
Benzo(a)pyrene	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(b)fluoranthene	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(g,h,i)perylene	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(k)fluoranthene	<0.02	<0.02	<0.02	<0.02	<0.02
Chrysene	<0.010	0.38	<0.010	<0.010	<0.01
Dibenzo(a,h)anthracene	<0.02	<0.02	<0.02	<0.02	<0.02
Fluoranthene	0.14	0.49	0.058	<0.010	0.46
Fluorene	0.082	0.029	<0.005	0.085	0.055
Indeno(1,2,3-c,d)pyrene	<0.02	0.42	0.098	<0.02	<0.02
Naphthalene	0.088	0.16	0.038	<0.005	0.055
Phenanthrene	<0.005	0.50	<0.005	0.020	0.26
Pyrene	<0.010	1.16	0.017	0.040	0.46

TABLE 27

PAHs IN SEDIMENTS AT THE MOUTHS OF THE TRIBUTARIES TO BOUNDARY BAY

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STD DEV
	(µg/g dry wt)			
Acenaphthene	<0.005	<0.005	<0.005	-
Acenaphthylene	<0.005	<0.005	<0.005	-
Anthracene	0.029	<0.005	<0.005	-
Benzo (a) anthracene	0.25	<0.010	<0.010	-
Benzo (a) Pyrene	0.11	<0.020	0.066	0.045
Benzo (b) Fluoranthene	<0.020	<0.020	<0.020	-
Benzo (g,h,i) Perylene	<0.020	<0.020	<0.020	-
Benzo (k) Fluoranthene	<0.020	<0.020	<0.020	-
Chrysene	0.20	<0.010	<0.010+	-
Dibenzo (a,h) Anthracene	<0.020	<0.020	<0.020	-
Fluoranthene	<0.010	<0.010	<0.010	-
Fluorene	0.034	<0.005	0.021	0.015
Indeno (1,2,3,c-d)Pyrene	0.096	0.021	0.067	0.040
Naphthalene	0.073	<0.005	0.043	0.035
Phenanthrene	<0.005	<0.005	<0.005	-
Pyrene	<0.010	<0.010	<0.010	-

+ MEDIAN VALUE

INDIVIDUAL ANALYSES

CHARACTERISTIC	R-1	R-2	R-3
Acenaphthene	<0.005	<0.005	<0.005
Acenaphthylene	<0.005	<0.005	<0.005
Anthracene	<0.005	0.029	<0.005
Benzo(a)anthracene	<0.010	<0.010	0.25
Benzo(a)pyrene	0.11	0.068	<0.02
Benzo(b)fluoranthene	<0.02	<0.02	<0.02
Benzo(g,h,i)perylene	<0.02	<0.02	<0.02
Benzo(k)fluoranthene	<0.02	<0.02	<0.02
Chrysene	<0.010	0.20	<0.010
Dibenzo(a,h)anthracene	<0.02	<0.02	<0.02
Fluoranthene	<0.010	<0.010	<0.010
Fluorene	0.025	<0.005	0.034
Indeno(1,2,3-c,d)pyrene	0.096	0.083	0.021
Naphthalene	0.073	<0.005	0.050
Phenanthrene	<0.005	<0.005	<0.005
Pyrene	<0.010	<0.010	<0.010

TABLE 28

SUMMARY OF ORGANOCHLORINE PESTICIDE CONCENTRATIONS IN SOFT-SHELLED CLAMS FROM BOUNDARY BAY

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
		(µg/g wet wt)		
ALDRIN				
SITE B-1	<0.0002	<0.0002	<0.0002	-
SITE B-5	<0.0002	<0.0002	<0.0002	-
ALPHA-CHLORDANE				
SITE B-1	0.0005	<0.0002	<0.0002+	-
SITE B-5	<0.0002	<0.0002	<0.0002	-
GAMMA-CHLORDANE				
SITE B-1	0.0003	<0.0002	<0.0002+	-
SITE B-5	<0.0002	<0.0002	<0.0002	-
DIELDRIN				
SITE B-1	<0.0002	<0.0002	<0.0002	-
SITE B-5	<0.0002	<0.0002	<0.0002	-
DDT				
SITE B-1	<0.0002	<0.0002	<0.0002	-
SITE B-5	<0.0002	<0.0002	<0.0002	-
DDD				
SITE B-1	<0.0002	<0.0002	<0.0002	-
SITE B-5	0.0003	<0.0002	<0.0002+	-
DDE				
SITE B-1	0.0004	<0.0001	<0.0001+	-
SITE B-5	0.0002	<0.0001	<0.0001+	-
ENDRIN				
SITE B-1	<0.0002	<0.0002	<0.0002	-
SITE B-5	<0.0002	<0.0002	<0.0002	-

+ MEDIAN VALUE

TABLE 28 (Continued)

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
		(µg/g wet wt)		
ENDOSULFAN-I				
SITE B-1	0.0003	<0.0001	<0.0001+	-
SITE B-5	0.0002	<0.0001	<0.0001+	-
ENDOSULFAN-II				
SITE B-1	0.0004	<0.0004	<0.0004+	-
SITE B-5	<0.0004	<0.0004	<0.0004	-
ENDOSULFAN SULFATE				
SITE B-1	<0.002	<0.002	<0.002	-
SITE B-5	<0.002	<0.002	<0.002	-
HEPTACHLOR				
SITE B-1	<0.0002	<0.0002	<0.0002	-
SITE B-5	<0.0002	<0.0002	<0.0002	-
HEPTACHLOR EPOXIDE				
SITE B-1	<0.002	<0.002	<0.002	-
SITE B-5	<0.002	<0.002	<0.002	-
LINDANE				
SITE B-1	0.0002	<0.0001	<0.0001+	-
SITE B-5	<0.0001	<0.0001	<0.0001	-
METHOXYCHLOR				
SITE B-1	<0.001	<0.001	<0.001	-
SITE B-5	<0.001	<0.001	<0.001	-
TOXAPHENE				
SITE B-1	<0.01	<0.01	<0.01	-
SITE B-5	<0.01	<0.01	<0.01	-

NUMBER OF SAMPLES: 7 AT B-1 +MEDIAN VALUE
5 AT B-5

TABLE 29

SUMMARY OF ORGANOCHLORINE PESTICIDE CONCENTRATIONS IN BOUNDARY BAY CRABS (*C. MAGISTER*)

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
		(µg/g wet wt)		
ALDRIN				
SITE B-9	<0.0002	<0.0002	<0.0002	-
SITE B-10	<0.0002	<0.0002	<0.0002	-
ALPHA-CHLORDANE				
SITE B-9 MUSCLE	0.0006	<0.0002	<0.0002+	-
HEPATOPANCREAS	<0.0002	<0.0002	<0.0002	-
SITE B-10 MUSCLE	0.0009	<0.0002	<0.0002+	-
HEPATOPANCREAS	<0.0002	<0.0002	<0.0002	-
GAMMA-CHLORDANE				
SITE B-9	<0.0002	<0.0002	<0.0002	-
SITE B-10	<0.0002	<0.0002	<0.0002	-
DIELDRIN				
SITE B-9 MUSCLE	0.0005	<0.0002	<0.0002+	-
HEPATOPANCREAS	<0.0002	<0.0002	<0.0002	-
SITE B-10 MUSCLE	0.0006	<0.0002	<0.0002+	-
HEPATOPANCREAS	<0.0002	<0.0002	<0.0002	-
DDT				
SITE B-9	<0.0002	<0.0002	<0.0002	-
SITE B-10	<0.0002	<0.0002	<0.0002	-
DDD				
SITE B-9 MUSCLE	0.0003	<0.0002	<0.0002+	-
HEPATOPANCREAS	<0.0002	<0.0002	<0.0002	-
SITE B-10 MUSCLE	<0.0002	<0.0002	<0.0002	-
HEPATOPANCREAS	0.0003	<0.0002	<0.0002+	-
DDE				
SITE B-9 MUSCLE	0.005	<0.0001	0.0022	0.0022
HEPATOPANCREAS	0.0081	-	-	-
SITE B-10 MUSCLE	0.0037	<0.0001	<0.0001+	-
HEPATOPANCREAS	0.021	0.0068	0.0123	0.0062

TABLE 29 (Continued)

CHARACTERISTIC	MAXIMUM	MINIMUM (µg/g wet wt)	MEAN	STANDARD DEVIATION
ENDRIN				
SITE B-9	<0.0002	<0.0002	<0.0002+	-
SITE B-10	<0.0002	<0.0002	<0.0002+	-
ENDOSULFAN-I				
SITE B-9 MUSCLE	0.0006	<0.0001	<0.0001+	-
HEPATOPANCREAS	<0.0001	-	-	-
SITE B-10 MUSCLE	0.0003	<0.0001	<0.0001+	-
HEPATOPANCREAS	<0.0001	<0.0001	<0.0001	-
ENDOSULFAN-II				
SITE B-9 MUSCLE	0.0006	<0.0004	<0.0004+	-
HEPATOPANCREAS	<0.0004	-	-	-
SITE B-10	<0.0004	<0.0004	<0.0004	-
ENDOSULFAN SULFATE				
SITE B-9	<0.002	<0.002	<0.002	-
SITE B-10	<0.002	<0.002	<0.002	-
HEPTACHLOR				
SITE B-9	<0.0002	<0.0002	<0.0002	-
SITE B-10	<0.0002	<0.0002	<0.0002	-
HEPTACHLOR EPOXIDE				
SITE B-9	<0.002	<0.002	<0.002	-
SITE B-10	<0.002	<0.002	<0.002	-
LINDANE				
SITE B-9 MUSCLE	0.0003	<0.0001	<0.0001+	-
HEPATOPANCREAS	<0.0001	-	-	-
SITE B-10	<0.0001	<0.0001	<0.0001	-
METHOXYCHLOR				
SITE B-9	<0.001	<0.001	<0.001	-
SITE B-10	<0.001	<0.001	<0.001	-
TOXAPHENE				
SITE B-9	<0.01	<0.01	<0.01	-
SITE B-10	<0.01	<0.01	<0.01	-

NUMBER OF SAMPLES: 1 HEPATOPANCREAS AND 7 MUSCLE SAMPLES AT SITE B-9
: 4 HEPATOPANCREAS AND 5 MUSCLE SAMPLES AT SITE B-10

ALL VALUES ARE LESS THAN DETECTION FOR MUSCLE AND HEPATOPANCREAS UNLESS OTHERWISE INDICATED

TABLE 30

SUMMARY OF ORGANOCHLORINE PESTICIDE CONCENTRATIONS IN BOUNDARY BAY FISH

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
		(µg/g wet wt)		
ALDRIN				
B-9				
SHINER PERCH (6)	<0.0002	<0.0002	<0.0002	-
3-SPINE ST'BACK(3)	<0.0002	<0.0002	<0.0002	-
STAGH'N SC'PIN(8)	<0.0002	<0.0002	<0.0002	-
B-10				
SNAKE PR'BACK(5)	<0.0002	<0.0002	<0.0002	-
BUTTER SOLE(5)	<0.0002	<0.0002	<0.0002	-
PACIFIC SANDAB(4)	<0.0002	<0.0002	<0.0002	-
STARRY FLOUNDER(5F)	<0.0002	<0.0002	<0.0002	-
(3L)	<0.0002	<0.0002	<0.0002	-
ALPHA-CHLORDANE				
B-9				
SHINER PERCH (6)	0.002	0.001	0.0016	0.0005
3-SPINE ST'BACK(3)	<0.0002	<0.0002	<0.0002	-
STAGH'N SC'PIN(8)	<0.0002	<0.0002	<0.0002	-
B-10				
SNAKE PR'BACK(5)	0.0006	<0.0002	<0.0002+	-
BUTTER SOLE(5)	0.0008	<0.0002	0.0004	0.0002
PACIFIC SANDAB(4)	0.0005	<0.0002	0.0003	0.0001
STARRY FLOUNDER(5F)	0.0011	<0.0002	<0.0002+	-
(3L)	<0.0002	<0.0002	<0.0002	-
GAMMA-CHLORDANE				
B-9				
SHINER PERCH (6)	0.0004	<0.0002	<0.0002+	-
3-SPINE ST'BACK(3)	<0.0002	<0.0002	<0.0002	-
STAGH'N SC'PIN(8)	<0.0002	<0.0002	<0.0002	-
B-10				
SNAKE PR'BACK(5)	0.0003	<0.0002	<0.0002+	-
BUTTER SOLE(5)	0.0004	<0.0002	0.0003	0.0001
PACIFIC SANDAB(4)	<0.0002	<0.0002	<0.0002	-
STARRY FLOUNDER(5F)	<0.0002	<0.0002	<0.0002	-
(3L)	0.0004	<0.0002	<0.0002+	-

+ MEDIAN VALUE

TABLE 30 (Continued)

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
		(µg/g wet wt)		
DIELDRIN				
B-9				
SHINER PERCH (6)	<0.0002	<0.0002	<0.0002	-
3-SPINE ST'BACK(3)	0.0002	<0.0002	<0.0002+	-
STAGH'N SC'PIN(8)	0.0003	<0.0002	<0.0002+	-
B-10				
SNAKE PR'BACK(5)	<0.0002	<0.0002	<0.0002	-
BUTTER SOLE(5)	0.0007	<0.0002	<0.0002+	-
PACIFIC SANDAB(4)	0.0003	<0.0002	<0.0002+	-
STARRY FLOUNDER(5F)	<0.0002	<0.0002	<0.0002	-
(3L)	<0.0002	<0.0002	<0.0002	-
DDT				
B-9				
SHINER PERCH (6)	<0.0002	<0.0002	<0.0002	-
3-SPINE ST'BACK(3)	<0.0002	<0.0002	<0.0002	-
STAGH'N SC'PIN(8)	0.003	<0.0002	<0.0002+	-
B-10				
SNAKE PR'BACK(5)	<0.0002	<0.0002	<0.0002	-
BUTTER SOLE(5)	<0.0002	<0.0002	<0.0002	-
PACIFIC SANDAB(4)	<0.0002	<0.0002	<0.0002	-
STARRY FLOUNDER(5F)	<0.0002	<0.0002	<0.0002	-
(3L)	<0.0002	<0.0002	<0.0002	-
DDD				
B-9				
SHINER PERCH (6)	<0.0002	<0.0002	<0.0002	-
3-SPINE ST'BACK(3)	0.0003	<0.0002	<0.0002+	-
STAGH'N SC'PIN(8)	0.002	<0.0002	0.0006	0.0007
B-10				
SNAKE PR'BACK(5)	<0.0002	<0.0002	<0.0002	-
BUTTER SOLE(5)	0.0009	<0.0002	<0.0002+	-
PACIFIC SANDAB(4)	<0.0002	<0.0002	<0.0002	-
STARRY FLOUNDER(5F)	0.0005	<0.0002	<0.0002+	-
(3L)	0.0005	<0.0002	<0.0002+	-

+ MEDIAN VALUE

TABLE 30 (Continued)

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
		(µg/g wet wt)		
DDE				
B-9				
SHINER PERCH (6)	0.0056	0.0015	0.0041	0.0006
3-SPINE ST'BACK(3)	0.0012	0.0006	0.0010	0.0003
STAGH'N SC'PIN(8)	0.0054	0.0006	0.0020	0.0021
B-10				
SNAKE PR'BACK(5)	0.0030	0.0015	0.0024	0.0007
BUTTER SOLE(5)	0.0004	0.0018	0.0008	0.0012
PACIFIC SANDAB(4)	0.0015	0.0006	0.0010	0.0004
STARRY FLOUNDER(5F)	0.0051	<0.0001	<0.0001+	-
(3L)	0.0120	0.0068	0.0093	0.0026
ENDRIN				
B-9				
SHINER PERCH (6)	<0.0002	<0.0002	<0.0002	-
3-SPINE ST'BACK(3)	<0.0002	<0.0002	<0.0002	-
STAGH'N SC'PIN(8)	<0.0002	<0.0002	<0.0002	-
B-10				
SNAKE PR'BACK(5)	<0.0002	<0.0002	<0.0002	-
BUTTER SOLE(5)	<0.0002	<0.0002	<0.0002	-
PACIFIC SANDAB(4)	0.0004	<0.0002	<0.0002+	-
STARRY FLOUNDER(5F)	<0.0002	<0.0002	<0.0002	-
(3L)	<0.0002	<0.0002	<0.0002	-
ENDOSULFAN-I				
B-9				
SHINER PERCH (6)	<0.0001	<0.0001	<0.0001	-
3-SPINE ST'BACK(3)	<0.0001	<0.0001	<0.0001	-
STAGH'N SC'PIN(8)	<0.0001	<0.0001	<0.0001	-
B-10				
SNAKE PR'BACK(5)	<0.0001	<0.0001	<0.0001	-
BUTTER SOLE(5)	0.0003	<0.0001	<0.0001+	-
PACIFIC SANDAB(4)	0.0003	<0.0001	<0.0001+	-
STARRY FLOUNDER(5F)	0.0004	<0.0001	<0.0001+	-
(3L)	<0.0001	<0.0001	<0.0001	-

+ MEDIAN VALUE

TABLE 30 (Continued)

CHARACTERISTIC	MAXIMUM	MINIMUM (µg/g wet wt)	MEAN	STANDARD DEVIATION
ENDOSULFAN-II				
B-9				
SHINER PERCH (6)	<0.0004	<0.0004	<0.0004	-
3-SPINE ST'BACK(3)	<0.0004	<0.0004	<0.0004	-
STAGH'N SC'PIN(8)	<0.0004	<0.0004	<0.0004	-
B-10				
SNAKE PR'BACK(5)	<0.0004	<0.0004	<0.0004	-
BUTTER SOLE(5)	<0.0004	<0.0004	<0.0004	-
PACIFIC SANDAB(4)	<0.0004	<0.0004	<0.0004	-
STARRY FLOUNDER(5F)	<0.0004	<0.0004	<0.0004	-
(3L)	<0.0004	<0.0004	<0.0004	-
ENDOSULFAN SULFATE				
B-9				
SHINER PERCH (6)	<0.002	<0.002	<0.002	-
3-SPINE ST'BACK(3)	<0.002	<0.002	<0.002	-
STAGH'N SC'PIN(8)	<0.002	<0.002	<0.002	-
B-10				
SNAKE PR'BACK(5)	<0.002	<0.002	<0.002	-
BUTTER SOLE(5)	<0.002	<0.002	<0.002	-
PACIFIC SANDAB(4)	<0.002	<0.002	<0.002	-
STARRY FLOUNDER(5F)	<0.002	<0.002	<0.002	-
(3L)	<0.002	<0.002	<0.002	-
HEPTACHLOR				
B-9				
SHINER PERCH (6)	<0.0002	<0.0002	<0.0002	-
3-SPINE ST'BACK(3)	<0.0002	<0.0002	<0.0002	-
STAGH'N SC'PIN(8)	<0.0002	<0.0002	<0.0002	-
B-10				
SNAKE PR'BACK(5)	<0.0002	<0.0002	<0.0002	-
BUTTER SOLE(5)	<0.0002	<0.0002	<0.0002	-
PACIFIC SANDAB(4)	<0.0002	<0.0002	<0.0002	-
STARRY FLOUNDER(5F)	<0.0002	<0.0002	<0.0002	-
(3L)	<0.0002	<0.0002	<0.0002	-

TABLE 30 (Continued)

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
		(µg/g wet wt)		
HEPTACHLOR EPOXIDE				
B-9				
SHINER PERCH (6)	<0.002	<0.002	<0.002	-
3-SPINE ST'BACK(3)	<0.002	<0.002	<0.002	-
STAGH'N SC'PIN(8)	<0.002	<0.002	<0.002	-
B-10				
SNAKE PR'BACK(5)	<0.002	<0.002	<0.002	-
BUTTER SOLE(5)	<0.002	<0.002	<0.002	-
PACIFIC SANDAB(4)	<0.002	<0.002	<0.002	-
STARRY FLOUNDER(5F)	<0.002	<0.002	<0.002	-
(3L)	<0.002	<0.002	<0.002	-
LINDANE				
B-9				
SHINER PERCH (6)	<0.0001	<0.0001	<0.0001	-
3-SPINE ST'BACK(3)	<0.0001	<0.0001	<0.0001	-
STAGH'N SC'PIN(8)	<0.0001	<0.0001	<0.0001	-
B-10				
SNAKE PR'BACK(5)	0.0002	<0.0001	0.0002	0.0001
BUTTER SOLE(5)	0.0002	<0.0001	<0.0001+	-
PACIFIC SANDAB(4)	0.0002	<0.0001	<0.0001+	-
STARRY FLOUNDER(5F)	<0.0001	<0.0001	<0.0001	-
(3L)	0.0003	<0.0001	0.0002	0.0001
METHOXYCHLOR				
B-9				
SHINER PERCH (6)	<0.001	<0.001	<0.001	-
3-SPINE ST'BACK(3)	<0.001	<0.001	<0.001	-
STAGH'N SC'PIN(8)	<0.001	<0.001	<0.001	-
B-10				
SNAKE PR'BACK(5)	<0.001	<0.001	<0.001	-
BUTTER SOLE(5)	<0.001	<0.001	<0.001	-
PACIFIC SANDAB(4)	<0.001	<0.001	<0.001	-
STARRY FLOUNDER(5F)	<0.001	<0.001	<0.001	-
(3L)	<0.001	<0.001	<0.001	-

+ MEDIAN VALUE

TABLE 30 (Continued)

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
		(µg/g wet wt)		
TOXAPHENE				
B-9				
SHINER PERCH (6)	<0.01	<0.01	<0.01	-
3-SPINE ST'BACK(3)	<0.01	<0.01	<0.01	-
STAGH'N SC'PIN(8)	<0.01	<0.01	<0.01	-
B-10				
SNAKE PR'BACK(5)	<0.01	<0.01	<0.01	-
BUTTER SOLE(5)	<0.01	<0.01	<0.01	-
PACIFIC SANDAB(4)	<0.01	<0.01	<0.01	-
STARRY FLOUNDER(5F)	<0.01	<0.01	<0.01	-
(3L)	<0.01	<0.01	<0.01	-

NUMBER OF SAMPLES INDICATED IN ( ).
3-SPINE ST'BACK INDICATES THREE-SPINE STICKLEBACK
STAGH'N SC'PIN INDICATES STAGHORN SCULPIN
SNAKE PR'BACK INDICATES SNAKE PRICKLEBACK
STARRY FLOUNDER(5F) REPRESENTS 5 MUSCLE SAMPLES
STARRY FLOUNDER(3L) REPRESENTS 3 LIVER SAMPLES

TABLE 31

SUMMARY OF ORGANOCHLORINE PESTICIDE CONCENTRATIONS IN BOUNDARY BAY SEDIMENTS

CHARACTERISTIC	NO. OF VALUES	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
			(µg/g dry wt)		
ALDRIN					
B-1	5	<0.001	<0.001	<0.001	-
B-2	5	<0.001	<0.001	<0.001	-
B-3	5	<0.001	<0.001	<0.001	-
B-4	5	<0.001	<0.001	<0.001	-
B-5	5	<0.001	<0.001	<0.001	-
B-6	5	<0.001	<0.001	<0.001	-
B-7	5	<0.001	<0.001	<0.001	-
B-8	5	<0.001	<0.001	<0.001	-
B-9	5	<0.001	<0.001	<0.001	-
B-10	5	<0.001	<0.001	<0.001	-
ALPHA-CHLORDANE					
B-1	5	<0.001	<0.001	<0.001	-
B-2	5	<0.001	<0.001	<0.001	-
B-3	5	<0.001	<0.001	<0.001	-
B-4	5	<0.001	<0.001	<0.001	-
B-5	5	<0.001	<0.001	<0.001	-
B-6	5	<0.001	<0.001	<0.001	-
B-7	5	<0.001	<0.001	<0.001	-
B-8	5	<0.001	<0.001	<0.001	-
B-9	5	<0.001	<0.001	<0.001	-
B-10	5	<0.001	<0.001	<0.001	-
GAMMA-CHLORDANE					
B-1	5	<0.001	<0.001	<0.001	-
B-2	5	<0.001	<0.001	<0.001	-
B-3	5	<0.001	<0.001	<0.001	-
B-4	5	<0.001	<0.001	<0.001	-
B-5	5	0.003	<0.001	<0.001+	-
B-6	5	<0.001	<0.001	<0.001	-
B-7	5	<0.001	<0.001	<0.001	-
B-8	5	<0.001	<0.001	<0.001	-
B-9	5	<0.001	<0.001	<0.001	-
B-10	5	<0.001	<0.001	<0.001	-

TABLE 31 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
			(µg/g dry wt)		
DIELDRIN					
B-1	5	<0.001	<0.001	<0.001	-
B-2	5	<0.001	<0.001	<0.001	-
B-3	5	<0.001	<0.001	<0.001	-
B-4	5	<0.001	<0.001	<0.001	-
B-5	5	<0.001	<0.001	<0.001	-
B-6	5	<0.001	<0.001	<0.001	-
B-7	5	<0.001	<0.001	<0.001	-
B-8	5	<0.001	<0.001	<0.001	-
B-9	5	<0.001	<0.001	<0.001	-
B-10	5	<0.001	<0.001	<0.001	-
DDT					
B-1	5	<0.001	<0.001	<0.001	-
B-2	5	<0.001	<0.001	<0.001	-
B-3	5	<0.001	<0.001	<0.001	-
B-4	5	<0.001	<0.001	<0.001	-
B-5	5	<0.001	<0.001	<0.001	-
B-6	5	0.002	<0.001	<0.001+	-
B-7	5	<0.001	<0.001	<0.001	-
B-8	5	<0.001	<0.001	<0.001	-
B-9	5	<0.001	<0.001	<0.001	-
B-10	5	<0.001	<0.001	<0.001	-
DDD					
B-1	5	<0.001	<0.001	<0.001	-
B-2	5	<0.001	<0.001	<0.001	-
B-3	5	<0.001	<0.001	<0.001	-
B-4	5	<0.001	<0.001	<0.001	-
B-5	5	<0.001	<0.001	<0.001	-
B-6	5	<0.001	<0.001	<0.001	-
B-7	5	<0.001	<0.001	<0.001	-
B-8	5	<0.001	<0.001	<0.001	-
B-9	5	<0.001	<0.001	<0.001	-
B-10	5	<0.001	<0.001	<0.001	-

+ MEDIAN VALUE

TABLE 31 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM (µg/g dry wt)	MINIMUM (µg/g dry wt)	MEAN	STANDARD DEVIATION
DDE					
B-1	5	<0.0005	<0.0005	<0.0005	-
B-2	5	<0.0005	<0.0005	<0.0005	-
B-3	5	<0.0005	<0.0005	<0.0005	-
B-4	5	<0.0005	<0.0005	<0.0005	-
B-5	5	<0.0005	<0.0005	<0.0005	-
B-6	5	<0.0005	<0.0005	<0.0005	-
B-7	5	<0.0005	<0.0005	<0.0005	-
B-8	5	<0.0005	<0.0005	<0.0005	-
B-9	5	<0.0005	<0.0005	<0.0005	-
B-10	5	0.001	<0.0005	<0.0005+	-
ENDRIN					
B-1	5	0.001	<0.0005	<0.0005+	-
B-2	5	<0.0005	<0.0005	<0.0005	-
B-3	5	<0.0005	<0.0005	<0.0005	-
B-4	5	<0.0005	<0.0005	<0.0005	-
B-5	5	<0.0005	<0.0005	<0.0005	-
B-6	5	<0.0005	<0.0005	<0.0005	-
B-7	5	<0.0005	<0.0005	<0.0005	-
B-8	5	<0.0005	<0.0005	<0.0005	-
B-9	5	<0.0005	<0.0005	<0.0005	-
B-10	5	<0.0005	<0.0005	<0.0005	-
ENDOSULFAN-I					
B-1	5	<0.001	<0.001	<0.001	-
B-2	5	<0.001	<0.001	<0.001	-
B-3	5	<0.001	<0.001	<0.001	-
B-4	5	<0.001	<0.001	<0.001	-
B-5	5	<0.001	<0.001	<0.001	-
B-6	5	<0.001	<0.001	<0.001	-
B-7	5	<0.001	<0.001	<0.001	-
B-8	5	<0.001	<0.001	<0.001	-
B-9	5	<0.001	<0.001	<0.001	-
B-10	5	<0.001	<0.001	<0.001	-

+ MEDIAN VALUE

TABLE 31 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STANDARD DEVIATION
ENDOSULFAN-II					
B-1	5	<0.001	<0.001	<0.001	-
B-2	5	<0.001	<0.001	<0.001	-
B-3	5	<0.001	<0.001	<0.001	-
B-4	5	<0.001	<0.001	<0.001	-
B-5	5	<0.001	<0.001	<0.001	-
B-6	5	<0.001	<0.001	<0.001	-
B-7	5	0.001	<0.001	<0.001+	-
B-8	5	<0.001	<0.001	<0.001	-
B-9	5	<0.001	<0.001	<0.001	-
B-10	5	<0.001	<0.001	<0.001	-
ENDOSULFAN SULFATE					
B-1	5	<0.010	<0.010	<0.010	-
B-2	5	<0.010	<0.010	<0.010	-
B-3	5	<0.010	<0.010	<0.010	-
B-4	5	<0.010	<0.010	<0.010	-
B-5	5	<0.010	<0.010	<0.010	-
B-6	5	<0.010	<0.010	<0.010	-
B-7	5	<0.010	<0.010	<0.010	-
B-8	5	<0.010	<0.010	<0.010	-
B-9	5	<0.010	<0.010	<0.010	-
B-10	5	<0.010	<0.010	<0.010	-
HEPTACHLOR					
B-1	5	<0.0005	<0.0005	<0.0005	-
B-2	5	<0.0005	<0.0005	<0.0005	-
B-3	5	0.013	<0.0005	<0.0005+	-
B-4	5	0.016	<0.0005	<0.0005+	-
B-5	5	<0.0005	<0.0005	<0.0005	-
B-6	5	<0.0005	<0.0005	<0.0005	-
B-7	5	<0.0005	<0.0005	<0.0005	-
B-8	5	<0.0005	<0.0005	<0.0005	-
B-9	5	<0.0005	<0.0005	<0.0005	-
B-10	5	0.003	<0.0005	<0.0005+	-

+ MEDIAN VALUE

TABLE 31 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STANDARD DEVIATION
HEPTACHLOR EPOXIDE					
B-1	5	<0.010	<0.010	<0.010	-
B-2	5	<0.010	<0.010	<0.010	-
B-3	5	0.014	<0.010	<0.010+	-
B-4	5	0.012	<0.010	<0.010+	-
B-5	5	<0.010	<0.010	<0.010	-
B-6	5	<0.010	<0.010	<0.010	-
B-7	5	<0.010	<0.010	<0.010	-
B-8	5	<0.010	<0.010	<0.010	-
B-9	5	<0.010	<0.010	<0.010	-
B-10	5	<0.010	<0.010	<0.010	-
LINDANE					
B-1	5	<0.001	<0.001	<0.001	-
B-2	5	<0.001	<0.001	<0.001	-
B-3	5	<0.001	<0.001	<0.001	-
B-4	5	<0.001	<0.001	<0.001	-
B-5	5	<0.001	<0.001	<0.001	-
B-6	5	<0.001	<0.001	<0.001	-
B-7	5	<0.001	<0.001	<0.001	-
B-8	5	<0.001	<0.001	<0.001	-
B-9	5	<0.001	<0.001	<0.001	-
B-10	5	<0.001	<0.001	<0.001	-
METHOXYCHLOR					
B-1	5	<0.005	<0.005	<0.005	-
B-2	5	<0.005	<0.005	<0.005	-
B-3	5	<0.005	<0.005	<0.005	-
B-4	5	<0.005	<0.005	<0.005	-
B-5	5	<0.005	<0.005	<0.005	-
B-6	5	<0.005	<0.005	<0.005	-
B-7	5	<0.005	<0.005	<0.005	-
B-8	5	<0.005	<0.005	<0.005	-
B-9	5	0.016	<0.005	<0.005+	-
B-10	5	<0.005	<0.005	<0.005	-

TABLE 31 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
			(µg/g dry wt)		
TOXAPHENE					
B-1	5	<0.030	<0.030	<0.030	-
B-2	5	<0.030	<0.030	<0.030	-
B-3	5	<0.030	<0.030	<0.030	-
B-4	5	<0.030	<0.030	<0.030	-
B-5	5	<0.030	<0.030	<0.030	-
B-6	5	<0.030	<0.030	<0.030	-
B-7	5	<0.030	<0.030	<0.030	-
B-8	5	<0.030	<0.030	<0.030	-
B-9	5	<0.030	<0.030	<0.030	-
B-10	5	<0.030	<0.030	<0.030	-

+ MEDIAN VALUE

CHARACTERISTIC	NO. OF VALUES	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
			(%)		
MOISTURE					
B-1	5	20.2	15.9	18.2	1.587
B-2	5	32.5	25.9	29.0	2.951
B-3	5	30.7	24.7	26.8	2.441
B-4	5	25.8	21.3	22.8	1.932
B-5	5	29.8	26.8	29.0	1.250
B-6	5	58.7	43.1	49.0	5.970
B-7	5	37.3	26.1	30.3	4.201
B-8	5	22.7	21.4	22.3	0.521
B-9	5	22.2	19.8	21.1	1.131
B-10	5	69.3	65.9	67.3	1.497

TABLE 32

SUMMARY OF ORGANOCHLORINE PESTICIDE CONCENTRATIONS IN DITCHES LEADING TO PUMP STATIONS

CHARACTERISTIC	MAXIMUM	MINIMUM (µg/g dry wt)	MEAN	STANDARD DEVIATION
ALDRIN	<0.001	<0.001	<0.001	-
ALPHA-CHLORDANE	0.003	<0.001	<0.001+	-
GAMMA-CHLORDANE	0.003	<0.001	<0.001+	-
DIELDRIN	0.002	<0.001	<0.001+	-
DDT	<0.001	<0.001	<0.001	-
DDD	0.004	<0.001	0.002	0.0013
DDE	0.005	<0.0005	0.0033	0.002
ENDRIN	<0.0005	<0.0005	<0.0005	-
ENDOSULFAN-I	<0.001	<0.001	<0.001	-
ENDOSULFAN-II	0.002	<0.001	<0.001	-
ENDOSULFAN SULFATE	<0.010	<0.010	<0.010	-
HEPTACHLOR	<0.0005	<0.0005	<0.0005	-
HEPTACHLOR EPOXIDE	<0.010	<0.010	<0.010	-
LINDANE	<0.001	<0.001	<0.001	-
METHOXYCHLOR	<0.005	<0.005	<0.005	-
TOXAPHENE	<0.030	<0.030	<0.030	-

+ MEDIAN VALUE

INDIVIDUAL DETECTABLE VALUES

PESTICIDE	P-1	P-2	P-3	P-4	P-5
ALPHA-CHLORDANE	<0.001	0.002	<0.001	0.003	<0.001
GAMMA-CHLORDANE	<0.001	0.002	<0.001	0.003	<0.001
DIELDRIN	<0.001	0.0008	<0.001	<0.001	0.002
DDD	0.003	0.002	<0.001	<0.001	0.004
DDE	0.002	0.004	<0.0005	0.005	0.005
ENDOSULFAN-II	0.0012	<0.001	<0.001	0.002	<0.001

TABLE 33

SUMMARY OF ORGANOCHLORINE PESTICIDE CONCENTRATIONS IN SEDIMENTS FROM THE MOUTHS OF BOUNDARY BAY TRIBUTARIES

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STANDARD DEVIATION
	(µg/g dry wt)			
ALDRIN	<0.001	<0.001	<0.001	-
ALPHA-CHLORDANE	<0.001	<0.001	<0.001	-
GAMMA-CHLORDANE	<0.001	<0.001	<0.001	-
DIELDRIN	<0.001	<0.001	<0.001	-
DDT	<0.001	<0.001	<0.001	-
DDD	<0.001	<0.001	<0.001	-
DDE	<0.0005	<0.0005	<0.0005	-
ENDRIN	<0.0005	<0.0005	<0.0005	-
ENDOSULFAN-I	<0.001	<0.001	<0.001	-
ENDOSULFAN-II	0.0015	<0.001	<0.001+	-
ENDOSULFAN SULFATE	<0.010	<0.010	<0.010	-
HEPTACHLOR	<0.0005	<0.0005	<0.0005	-
HEPTACHLOR EPOXIDE	<0.010	<0.010	<0.010	-
LINDANE	<0.001	<0.001	<0.001	-
METHOXYCHLOR	<0.005	<0.005	<0.005	-
TOXAPHENE	<0.030	<0.030	<0.030	-

+ MEDIAN VALUE : DETECTABLE VALUE OF 0.0015 µg/g WAS MEASURED AT P-6.

ONE SAMPLE WAS COLLECTED FROM NEAR THE MOUTHS OF EACH OF THE SERPENTINE, NICOMEKL, AND LITTLE CAMPBELL RIVERS.

APPENDIX

DETAILED DESCRIPTION OF COMPOSITE SAMPLES
(Sample numbers can be cross referenced to report with individual analyses from ASL)

LENGTH (cm)	WEIGHT (gm)	TISSUE WEIGHT (gm)
SITE B-1 M. ARENARIA		
Sample # 1-2		
8.5 x 7 x 5	156.8	44.2
5.6 x 4.1 x 3.1	85.0	15.2
		Σ=59.4
Sample # 1-A		
12.9 x 10 (gaping shell)	368.4	207.1
Sample # 1-B		
13.0 x 10.4 (gaping shell)	336.7	174.3
Sample # 1-C		
12.4 x 9.8 (gaping shell)	300.5	174.2
Sample # 1-D		
12 x 9 (gaping shell)	340.1	202.5
Sample # 1-E		
7.7 x 7.0 (gaping shell)	100.0	36.3
7.5 x 6.5 (gaping shell)	106.3	36.0
7.8 x 6.8 (gaping shell)	148.6	43.0
8.2 x 6.9 (gaping shell)	165.4	59.9
		Σ=175.2
SITE B-1 C. NUTTALLII (Sample # 1-1)		
7.0 x 6.8 x 4.5	102.4	35.3
4.5 x 4.3 x 3.2	36.7	20.1
3.0 x 3.2 x 2.0	14.1	4.5
		Σ= 59.9
SITE B-1 TRESUS CAPEX (Sample # 1-3)		
10.0 X 6.2 X 4.0	117.4	22.0
7.6 X 11.8 X 5.0	300.2	93.8
		Σ=115.8

APPENDIX (Continued)

LENGTH (cm)	WEIGHT (gm)	TISSUE WEIGHT (gm)
SITE B-5 M. ARENARIA		
Sample # 5-1		
6.5 X 3.6 X 2.0	45.2	9.8
6.7 X 4.3 X 2.0	48.3	12.8
6.5 X 4.3 X 2.5	38.6	16.0
6.5 X 4.0 X 2.2	39.0	10.6
6.3 X 3.8 X 2.2	39.9	12.7
6.3 X 3.6 X 2.0	25.4	7.2
5.5 X 3.2 X 1.6	20.0	7.3
4.5 X 2.7 X 1.5	11.4	5.0
5.5 X 3.5 X 1.5	unknown	8.2
5.2 x 3.5 x 1.8	21.3	7.3
5.1 x 2.8 x 1.5	14.4	4.7
4.5 x 2.8 x 1.8	11.4	3.9
4.2 x 2.4 x 1.7	9.4	4.6
4.3 x 2.6 x 1.5	11.1	3.4
3.9 x 2.4 x 1.3	7.8	3.3
3.7 x 2.1 x 1.0	6.3	2.5
3.6 x 2.0 x 1.1	5.9	2.1
3.6 x 2.1 x 0.9	3.9	2.1
3.1 x 1.8 x 0.8	4.4	1.7
3.0 x 1.7 x 0.8	2.9	1.0
2.2 x 0.7 x 0.5	1.2	0.3
		Σ=124.5
Sample # 5-3		
6.9 x 3.8 x 2.6	43.6	17.4
7.2 x 4.3 x 2.7	47.4	19.0
6.6 x 3.8 x 1.9	35.7	14.2
6.5 x 3.8 x 2.6	43.7	16.7
5.7 x 3.9 x 2.8	36.4	15.1
7.6 x 4.0 x 2.5	50.7	21.2
5.9 x 3.9 x 1.7	33.5	15.6
5.9 x 3.5 x 2.0	26.8	11.7
6.1 x 3.5 x 2.0	27.7	10.9
6.2 x 3.6 x 2.1	28.5	12.5
		Σ=154.3

APPENDIX (Continued)

LENGTH (cm)	WEIGHT (gm)	TISSUE WEIGHT (gm)
SITE B-5 M. ARENARIA		
Sample # 5-2		
5.8 x 3.8 x 2.2	34.7	14.6
6.0 x 3.5 x 1.5	31.0	12.6
7.2 x 4.3 x 1.7	47.6	16.1
7.0 x 4.6 x 2.5	48.4	17.0
6.3 x 3.9 x 2.2	30.4	11.1
5.7 x 3.3 x 1.8	27.3	9.3
6.0 x 2.9 x 1.7	21.6	9.7
5.5 x 3.6 x 1.8	24.7	10.3
5.5 x 3.4 x 1.7	24.6	9.0
4.8 x 2.7 x 1.6	18.0	7.3
7.7 x 4.8 x 2.9	50.3	22.5
		Σ=149.5
Sample # 5-4		
5.1 x 3.2 x 1.8	24.4	8.7
6.1 x 3.6 x 2.2	30.0	11.5
6.1 x 3.6 x 2.2	34.9	15.4
6.7 x 3.9 x 2.6	38.1	17.4
5.6 x 3.2 x 1.7	19.0	8.8
5.8 x 3.9 x 1.5	22.4	7.4
5.5 x 3.4 x 1.6	22.9	8.5
5.6 x 3.3 x 2.1	23.8	11.0
5.9 x 3.4 x 1.9	24.0	9.5
5.8 x 3.3 x 2.1	22.0	10.4
5.2 x 3.3 x 1.9	19.7	8.4
5.6 x 3.1 x 1.7	17.0	8.2
5.4 x 3.3 x 1.8	20.4	10.6
5.4 x 3.2 x 1.9	20.7	9.1
5.5 x 3.3 x 1.8	21.6	8.7
		Σ=152.6

APPENDIX (Continued)

LENGTH (cm)	WEIGHT (gm)	TISSUE WEIGHT (gm)
SITE B-5 M. ARENARIA		
Sample # 5-5		
5.9 x 3.6 x 1.8	21.2	9.4
6.1 x 3.7 x 1.8	22.8	10.9
5.2 x 3.4 x 1.8	19.0	8.7
4.9 x 3.1 x 1.6	16.0	6.7
5.6 x 3.2 x 2.1	22.6	10.0
5.2 x 3.1 x 1.4	13.3	7.1
5.3 x 3.1 x 1.6	15.8	7.2
5.1 x 3.2 x 2.0	23.6	9.7
5.2 x 3.0 x 2.0	18.0	unknown
5.4 x 3.3 x 1.9	21.1	7.1
5.0 x 3.0 x 1.9	18.0	6.5
4.8 x 3.1 x 1.8	17.3	7.1
4.8 x 2.9 x 1.8	14.6	7.9
4.7 x 3.0 x 1.6	14.0	4.6
4.8 x 3.0 x 1.9	16.2	5.8
5.3 x 3.2 x 1.8	16.8	7.0
4.8 x 3.0 x 1.8	15.2	6.0
5.0 x 2.9 x 1.7	16.0	4.9
4.4 x 2.6 x 1.6	10.7	unknown
4.2 x 2.5 x 1.6	12.1	3.7
4.3 x 2.6 x 1.5	12.2	4.0
		Σ=147.8

SITE B-9 C. Magister

SAMPLE #	LENGTH (cm)	SEX	WHOLE WEIGHT (gm)	MUSCLE WEIGHT (gm)	HEPATOPANCREAS WT. (gm)
9-1	14.2	M	403.1	54.9	5.9
9-2	12.3	F	284.1	70.7	13.2
9-3	13.2	M	370.2	104.0	16.3
9-4	12.6	M	318.5	89.1	10.0
9-5	13.6	M	354.3	87.7	14.6
9-6					Σ=59.0

APPENDIX (Continued)

SITE B-9 — **C. Magister**

SAMPLE #	LENGTH (cm)	SEX	WHOLE WEIGHT (gm)	MUSCLE WEIGHT (gm)	HEPATOPANCREAS WT. (gm)
9-50	13.5	F	297.1	67.7	20.4
	14.8	F	403.9	95.2	38.1
				Σ=162.9	
9-51	14.3	F	319.5	64.4	17.5
	14.6	F	348.6	73.9	22.2
				Σ=138.3	
9-52	12.8	F	257.3	not dissected	16.2
					Σ=104.5

SITE B-9 — **Cymatogaster aggregata**

Sample # 9-10	120 individuals	Σ = 154.6 grams
Sample # 9-11	120 individuals	Σ = 158.9 grams
Sample # 9-12	120 individuals	Σ = 151.3 grams
Sample # 9-14	120 individuals	Σ = 150.1 grams
Sample # 9-43	36 individuals	Σ = 56.8 grams
Sample # 9-45	unknown number	unknown weight

SITE B-9 — **Gasterosteus aculeatus**

Sample # 9-15	30 individuals	Σ = 149.0 grams
Sample # 9-44	23 individuals	Σ = 54.9 grams
Sample # 9-46	441 individuals (423 juveniles)	Σ = 150.5 grams

SITE B-9 — **Leptocottus armattus**

Sample # 9-16	30 individuals	Σ = 138.9 grams
Sample # 9-18	13.7 cm	36.2 grams
	11.8 cm	26.7 grams
	12.6 cm	28.1 grams
	11.8 cm	25.3 grams
		Σ = 116.3 grams

SITE B-9 **Leptocottus armattus**

Sample # **9-19**

14.4 cm 72.1 grams
20.5 cm 120.8 grams
Σ = **192.9** grams

Sample # **9-40**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
7.6	5.2	8.1	7.0	10.7	13.3	9.6	11.3
6.5	7.1	7.6	5.2	8.1	5.9	8.9	8.3
8.1	5.9	8.1	6.4	8.0	6.3	7.6	5.4
9.3	9.6	8.2	5.8	8.5	7.5	8.4	6.7
8.0	6.8	9.7	10.0	8.6	6.8	8.6	6.8
6.7	3.3	Σ = **150.6** grams					

Sample # **9-41**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
8.4	6.5	7.3	5.0	6.9	3.6	7.9	5.5
6.7	3.1	6.5	3.2	6.6	3.7	9.5	9.8
8.9	7.5	7.3	7.0	9.1	8.8	8.7	7.6
9.6	10.5	9.1	8.4	9.1	8.3	8.8	8.2
9.2	10.5	8.9	9.5	8.6	6.5	7.5	5.3
7.9	5.8	7.4	4.1	5.9	2.7	Σ = **151.1** grams	

Sample # **9-42**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
9.2	8.6	9.0	9.2	7.6	5.5	7.5	5.5
8.3	6.4	8.1	6.8	7.6	5.6	7.8	5.9
7.5	6.1	6.8	4.2	6.2	2.8	7.3	4.7
7.8	6.5	5.8	3.0	7.4	5.0	6.4	3.3
5.8	2.6	7.1	3.6	Σ = **94.3** grams			

Sample **9-48**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
9.1	9.1	8.8	8.6	7.4	4.6	6.2	3.2
8.6	7.0	6.7	3.2	6.6	3.4	6.7	3.8
6.6	3.6			Σ = **46.5** grams			

APPENDIX (Continued)

SITE B-9 **Platichthys stellatus**

Sample # **9-47**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
7.2	6.1	7.8	6.0	7.1	5.6	6.9	5.3
5.8	3.1	7.2	4.4	8.1	7.0	7.2	4.6
6.7	3.8	6.2	3.0	6.8	4.0	5.9	2.4
5.2	2.0	4.9	1.6	4.9	1.5	9.4	12.0
7.8	6.4	7.6	6.2	6.8	4.8	7.7	6.1
5.7	2.7	6.5	5.3	4.8	1.7	4.7	1.6
5.2	2.0	4.2	0.7	4.9	1.9	8.6	8.5
7.3	5.7	6.8	4.8	7.1	5.1	7.3	5.0
6.5	3.7	6.4	3.6	5.9	2.6	Σ = **151.0** grams	

SITE B-9 **Unidentified Perch**

Sample # **9-49**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
7.8	6.7	7.5	4.5	8.1	6.6	7.8	4.8
				Σ = **22.6** grams			

SITE B-10 **Lumpenus sagitta**

Sample # **10-1**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
25.8	23.2	20.0	14.9	21.7	22.8	19.8	16.5
15.6	8.7	14.6	7.4	18.4	14.5	15.2	10.5
16.5	10.8	16.6	10.1	14.8	7.7	14.3	6.6
15.4	8.4			Σ = **162.1** grams			

Sample # **10-2**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
22.3	21.4	19.5	14.3	29.0	35.2	26.6	30.3
25.0	29.1	25.5	30.8	Σ = **161.1** grams			

APPENDIX (Continued)

SITE B-10 — **Lumpenus sagitta**

Sample # **10-3**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
12.6	12.8	19.0	14.6	16.2	11.8	15.0	9.0
15.2	9.6	14.3	6.9	16.1	10.6	15.4	10.8
16.8	12.1	15.2	7.2	14.5	7.6	17.2	12.4
15.1	8.7	18.1	13.5	17.4	11.8	Σ = **159.4** grams	

Sample # **10-4**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
22.8	23.5	26.9	40.3	26.1	32.6	25.8	29.6
23.9	28.5			Σ = **154.5** grams			

Sample # **10-5**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
21.0	15.9	21.2	22.1	21.4	20.5	20.3	18.2
20.7	17.4	21.4	23.3	21.7	17.5	21.6	21.0
				Σ = **156.2** grams			

Sample # **10-7**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
27.7	27.8	27.0	30.7	26.2	41.7	29.5	36.9
28.1	40.6			Σ = **177.7** grams			

Sample # **10-8**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
23.2	21.2	23.3	29.1	24.3	22.4	24.8	24.1
23.4	24.8	24.7	23.0	23.2	22.5	Σ = **167.1** grams	

Sample # **10-15**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
18.2	14.3	19.8	18.4	19.7	15.1	18.0	15.1
18.8	15.9	17.0	12.0	19.1	12.4	17.6	13.7
18.2	12.9	18.1	12.7	18.6	16.5	Σ = **159.0** grams	

APPENDIX (Continued)

SITE B-10 **Leptocottus armatus**

Sample # **10-12**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
18.6	77.7	16.7	55.9				

Σ = **133.6** grams

Sample # **10-13**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
19.4	90.2	9.3	10.5	10.7	12.9		

Σ = **113.6** grams

SITE B-10 **Hexagrammos decagrammus**

Sample # **10-9**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
13.0	22.1	12.8	21.3	12.7	22.4	12.5	22.1

Σ = **87.9** grams

SITE B-10 **Microgadus proximus**

Sample # 10-10

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
14.5	27.0	19.2	59.9				

Σ = 86.9 grams Insufficient Sample

SITE B-10 **Lycodes brevipes**

Sample # 10-14

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
21.5	42.8	Insufficient Sample - not analyzed					

SITE B-10 **Isopsetta isolepsis**

Sample # 10-16

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
7.0	5.8	6.8	3.4	4.2	1.6	3.8	0.9
4.8	0.9	5.4	1.4	3.7	0.6	4.2	0.8
4.0	0.6	11.5	27.5	11.6	14.6		

Σ = 58.1 grams

Insufficient Sample - not analyzed

APPENDIX (Continued)

SITE B-10 — **Isopsetta isolepsis**

Sample # **10-17**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
9.8	19.0	13.0	10.9	11.3	11.5	12.9	15.4
13.7	23.1	13.0	21.5	14.5	27.5	13.9	23.0
			Σ = **151.9**				

Sample # **10-18**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
16.2	35.8	16.1	39.6	15.4	34.9	14.4	27.5
13.8	22.0			Σ = **162.5** grams			

Sample # **10-19**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
15.8	38.5	14.8	28.3	14.3	28.6	15.1	32.3
14.8	30.1			Σ = **157.8** grams			

Sample # **10-20**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
13.5	18.4	13.5	23.9	11.6	13.4	10.1	11.1
13.1	26.1	13.0	19.1	10.1	11.7	10.9	14.8
11.5	15.3			Σ = **153.8** grams			

Sample # **10-23**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
13.5	22.5	14.0	29.8	14.9	31.5	15.1	34.4
15.8	33.7			Σ = **151.9** grams			

SITE B-10 — **Porichthys notatus**

Sample # **10-6**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
13.0	17.2	12.2	17.1	14.5	30.1	13.0	18.9
12.3	16.4	14.8	25.2	Σ = **125.1** grams			

Sample # **10-11**

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
14.9	36.5	11.6	16.9	13.2	20.4	6.7	3.0
15.2 cm and 12.9 cm for wt of 58.0 grams						Σ = **134.8** grams	

APPENDIX (Continued)

SITE B-10 — **CITHARICHTHYS SORDIDUS**

Sample # 10-21

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
9.9	12.1	10.9	14.0	11.5	18.6	10.8	12.0
9.7	10.0	9.8	10.5	11.2	14.0	10.4	10.7
11.2	14.9	10.7	10.4	10.0	11.1	9.7	10.8
10.2	11.0						

Σ = **160.1** grams

Sample # 10-22

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
17.7	52.2	16.5	37.8	19.0	73.2		

Σ = **163.2** grams

Sample # 10-24

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
15.8	59.9	14.2	35.3	15.0	33.7	15.2	34.6

Σ = **163.5** grams

Sample # 10-26

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
10.5	13.7	10.6	13.4	11.3	18.0	10.1	11.5
8.8	5.1	8.8	10.0	13.7	32.7	14.0	29.7
16.2	52.2						

Σ = **186.3** grams

Sample # 10-29

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
13.0	48.2	10.1	13.6	14.6	39.2	9.6	9.8

Σ = **110.8** grams

Sample # 10-30

L (cm)	Wt (gm)	L (cm)	Wt (gm)	L (cm)	Wt(gm)	L(cm)	Wt (gm)
15.1	31.8	17.2	46.4	16.8	46.3	16.1	42.8

Σ = **167.3** grams

APPENDIX (Continued)

SITE B-10			C. Magister		
SAMPLE #	LENGTH (cm)	SEX	WHOLE WEIGHT (gm)	MUSCLE WEIGHT (gm)	HEPATOPANCREAS WT. (gm)
10-31	16.5	M	587.0	147.3	26.4
10-32	18.8	M	831.8	210.8	65.0
10-33	17.7	M	718.7	168.0	56.8
10-36		M			Σ = 148.2
10-34	18.0	M	781.1	148.4	41.6
10-35	16.6	M	485.9	157.5	38.3
10-37	15.6	M	462.3	MUSCLE	17.7
	15.4	M	427.4	FROZEN	26.6
					Σ = 124.5
10-38	14.4	M	327.7	MUSCLE	19.5
	13.2	F	302.1	FROZEN	19.5
	13.3	F	338.3		17.1
	13.8	M	336.9	MUSCLE	18.6
	13.4	F	379.7	FROZEN	13.9
	13.8	F	339.5		8.3
	12.5	M	199.7		24.1
					Σ = 121.0
10-39	11.4	F	204.6	MUSCLE	10.7
	11.8	M	187.2	FROZEN	19.7
	11.7	M	205.4		19.4
	12.3	F	243.5	MUSCLE	7.8
	11.8	F	204.4	FROZEN	16.1
	12.2	M	167.9		15.6
	11.2	M	243.6	MUSCLE	23.4
	14.2	F	354.8	FROZEN	13.0
	14.4	F	327.6		33.7
					Σ = 159.4

APPENDIX (Continued)

SITE B-10 SAMPLE #	LENGTH (cm)	Platichthys stellatus WHOLE WEIGHT (gm)	MUSCLE WEIGHT (gm)	LIVER WEIGHT (gm)
10-40	40.3	1005.5	162.9	30.4
10-41	38.5	874.7	166.0	13.3
10-42	37.2	738.3	169.7	18.8
10-43	29.6	402.8	129.7	4.7
10-45				Σ = 67.2
10-44	32.5	507.7	150.8	6.9
10-46	33.0	434.3	MUSCLE	11.3
	31.5	390.4	FROZEN	unknown
	31.4	352.4		2.6
	31.6	456.7	MUSCLE	4.9
	31.8	360.0	FROZEN	4.6
	30.8	419.2		7.7
	30.0	392.8	MUSCLE	8.2
	31.0	324.8	FROZEN	1.2
	28.4	304.2		4.5
	28.6	305.1	MUSCLE	3.0
	29.2	395.5	FROZEN	6.8
	28.3	285.7		4.2
	30.0	332.1	MUSCLE	3.7
	28.0	323.4	FROZEN	4.3
	29.3	269.9		2.8
				Σ > 76.4

APPENDIX (Continued)

SITE B-10		Platichthys stellatus		
SAMPLE #	LENGTH (cm)	WHOLE WEIGHT (gm)	MUSCLE WEIGHT (gm)	LIVER WEIGHT (gm)
10-47	23.9	199.4	MUSCLE	3.2
	24.8	219.0	FROZEN	2.3
	24.3	184.8		1.6
	23.2	142.5	MUSCLE	2.7
	24.7	205.4	FROZEN	2.8
	25.9	211.5		2.3
	22.8	153.1	MUSCLE	1.8
	24.3	162.9	FROZEN	1.7
	22.7	152.1		0.6
	23.5	146.3	MUSCLE	2.4
	25.2	207.5	FROZEN	2.3
	26.3	225.8		2.7
	28.5	268.5	MUSCLE	3.1
	27.4	278.6	FROZEN	3.6
	30.2	328.7		4.5
	28.1	300.6	MUSCLE	4.5
	31.2	314.0	FROZEN	2.6
	27.1	257.2		2.7
	29.2	332.1	MUSCLE	8.1
	27.3	254.9	FROZEN	5.0
	25.3	229.5		2.8
				Σ = 63.5